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MODELING THE WORLD GRAIN-OILSEEDS-LIVESTOCK ECONOMY TO ASSESS WORLD FOOD PROSPECTS

By Anthony S. Rojko and Martin W. Schwartz*

Mathematical programming methods are used as a framework to evaluate world food prospects. Emphasis is on analyzing the world grain-oilseeds-livestock economy to capture the interaction of the predominantly cereal economies of the developing world and the livestock economies of the developed world as they compete for the world's agricultural resources. The mathematical model, called the Grain-Oilseeds-Livestock (GOL) model, incorporates general population and income growth rates, demand and supply price elasticities, input variables, and assumptions about basic underlying economic trends and policy constraints.
Keywords: Projections, grain-oilseed-livestock model, trade models.

A model of the world grain-oilseed-livestock economy (GOL) has been developed within the Economic Research Service (ERS) to generate projections of world food production, consumption, and trade to 1985 and 2000.[1] World equilibrium models exist for individual commodities or limited commodity aggregates, and individual country models integrate the grain, oilseed, and livestock sectors. The GOL model, however, is one of the first equilibrium models to consider the broader feed-livestock relationships at the regional and world level. It relates the grain-oriented food economies of developing regions with the livestock-oriented food economies of developed regions in a more complete and logically consistent manner than has been done in the past.[2]

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[1] This article reports on one phase of an ongoing research effort aimed at generating and maintaining up-to-date price, production, consumption, and trade projections for the major regions of the world. This effort requires substantial ongoing teamwork from members of the Commoditics Program Area working with others in FDCD and other ERS divisions in the area of econometric model development and country-specific analyses. Significant inputs have been made by Donald Regier (livestock), Patrick O'Brien (grains), Arthur Coffing (oilseeds), Robert Barry (rice), Myles Mielke (dairy), and Linda Bailey. Several people have helped to develop the computer programs, beginning with Frances Urban in the early stages, Hilarius Fuchs during the main development stage, followed by Fenton Sands and Martin Schwartz. The work summarized here has been reported in detail in several other ERS publications—(*8, 20-22*). It was discussed in context with other ERS forecasting and projections models in (*6*).

Note: Italicized numbers in parentheses refer to items in References at the end of this article.

GOL is an operational model used as an integral part of ongoing ERS projections work (*6*). The export projections tie in with detailed U.S. models. It is also used as an analytic tool providing a quantitative dimension to otherwise qualitative international policy analysis.

Using population and income growth rates, supply and demand elasticities, physical input-output rates, and policy assumptions as inputs, the model projects area, production, food and feed use, trade levels, and prices for each commodity. Eleven basic commodities are included: wheat, rice, coarse grains, oilmeal, soybeans, beef and veal, pork, poultry, milk, butter, and cheese. The world was divided into 27 regions: eight developed, three centrally planned, and 16 developing. All regions have some crop equations, but not all regions have livestock equations. The centrally planned regions have collapsed international trade equations only.

The equations in the model were developed to reflect (1) the economic behavioral patterns of the grain-oilseeds-livestock economy, (2) the important technical input-output relationships, and (3) the institutional setting and policy constraints. An attempt was made to model changes in consumption preferences (such as increasing desire for livestock products and increasing use of grain in livestock products and increasing use of grain in livestock production; changes in resource mixes, and changes in both crop and livestock productivity. The individual regional commodity coefficients were synthesized from existing studies and analyses, notably (*3, 5, 11-13, 14, 16, 18, 19, 23* and *24*).

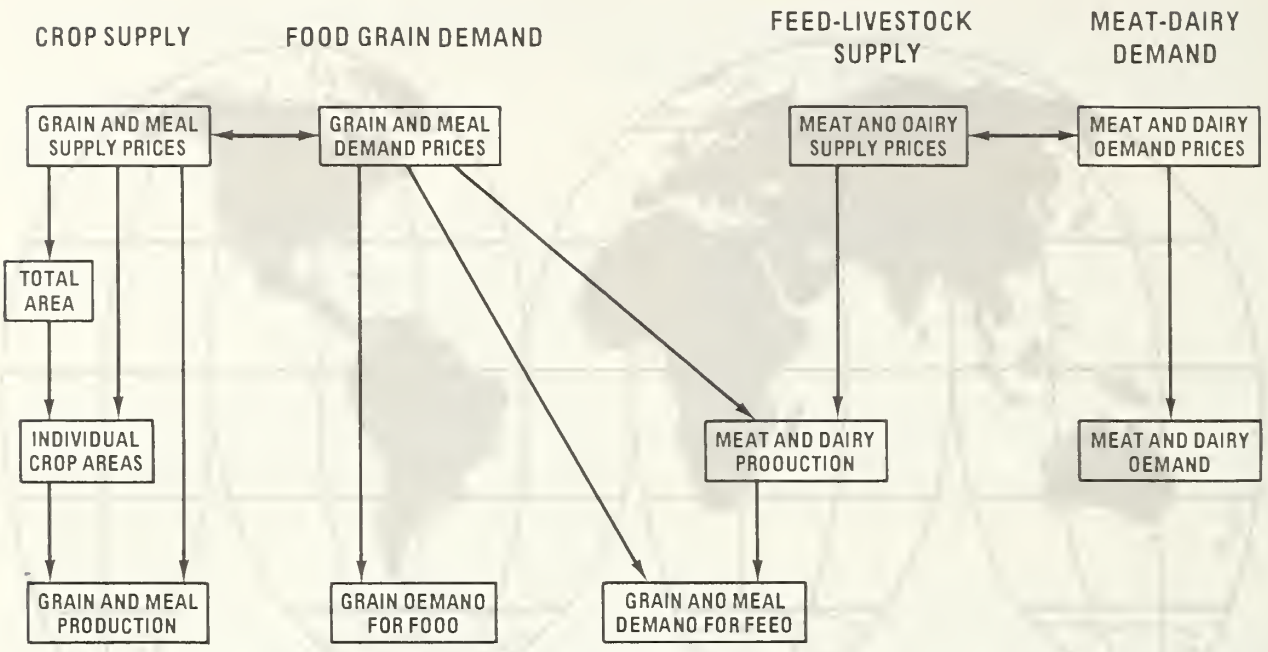
MODEL STRUCTURE[3]

Within GOL, most commodities have supply, demand, and trade sectors modeled. The figure following shows the relationships among the endogenous variables for a typical region. The crop supply sector appears at the far

[2] A primary purpose in development of the model was to provide a quantitative basis for assessing the world food prospects of the developing world in the context of the total world grain and livestock complex. Several reports (*4, 9, 28*) have been concerned with this issue, as well as two ERS reports (*7*) and (*8*) that used results from this model.

[3] This model builds upon the world grain model developed by Rojko, Urban, and Naive (*20*). The approach has also been influenced by model development by Bawden (*2*), Judge and Takayama (*15, 26, 27*), and others (*10*).

SUPPLY AND DEMAND SECTORS FOR A TYPICAL REGION IN GOL MODEL



left of the chart. The key endogenous variable is total area, defined as a function of the prices for the region's most important crops. Individual crops compete for total area based on historic shares and projected relative prices of the crops. Production is determined from the area and from crop prices; prices are included to allow response to higher input use when prices are higher. Typical grain supply equations[4] for a region are:

Total area = F (wheat and other crop prices)
Wheat area = (total area, price of wheat, corn, and meal)
Wheat production = F (wheat area, wheat price, exogenous input bundle)

Grains demanded for human food are functions of grain prices, income, and population. The price elasticities allow variance in both total food demand for grain and the relative shares of individual grains. Demand for meats and dairy products, shown on the far right of the chart, are modeled similarly. Typical equations are:

Wheat demand for food = F (price of wheat, corn, price, rice; income; population)
Beef demand = F (price of beef, pork, and poultry; price, income; population)

[4] Note: Crop areas sum to total area in these equations.

The feed demand-livestock production sector, second from the right in the figure, is more complex. Meat production is a function of meat prices, feed prices, and productivity. The incorporation of individual meat prices allows competition between the meats. Grain and oilseed feed prices influence the cost of producing meats. Typical equations are:

Beef production = F (price of beef, pork, corn, and meal; productivity)

Feed demand is a function of appropriate grain prices, meat prices, and livestock production. Crop prices allow competition between feeds. The coefficients for livestock products are nominal feeding rates; that is, the tons of grain used to produce a ton of livestock products. Livestock product prices are used to adjust feed demand, essentially modifying the feeding rate, which forms a second set of relations between crop prices and livestock prices. Typical equations are:

Oilmeal demand for feed = F (production of beef, pork, poultry, eggs, and milk, price of pork, corn, and meal)

Supply and demand prices for crops and meats, shown as arrows in the figure, are usually related through con-

stant margins. Price margins fluctuate, however, in the few selected regions where historical data indicates that margins widen, narrow, or do both, as price levels change.

Total milk production, similar to that of crops and meat, is a function of milk price, feed prices, and productivity growth. However, dairy products and prices are treated somewhat differently because of the physical production process. Total milk production is processed into cheese or butter or sold as fluid milk products. The supply function for fluid milk is, in fact, also the demand function because fluid demand is filled first. Thus, the function is defined as a function of milk price, income, and population. Production of cheese and butter depends on the relative demand for these products; thus, relative product prices and other demand factors determine their output. Cheese production is a function of cheese and butter price, population, and income. Population and income are included to reflect the continuing longrun growth in demand for cheese. Mathematically, butter production is treated as a residual. Through use of physical conversion factors, total milk production not required for fluid milk and cheese becomes butter. The supply prices of total milk, butter, and cheese and the demand price of fluid milk products are related to reflect product yield.

Economic activity between regions is related through trade prices and a world equilibrium for each commodity traded. The commodity-specific world equilibrium equations state that total world production minus total world demand equals the change in stocks. Stock changes are either predetermined or treated as residual, depending on the purpose of the particular simulation. Each region's import or export prices are related to the region's demand price, either through constant margins or through decreasing margins as trade prices increase. That is, it is assumed that whenever import prices increase, the entire increase will not be passed on to consumers. Finally, trade prices in the different regions are related.

GOL incorporates a number of exceptions to the treatment outlined above. These exceptions are included to more accurately model a particular region. For example, variable levies are included in the equations for the European Economic Community (EC). In addition, special equations linking the original six countries (EC-6) and the new members (EC-3), which are modeled as separate regions, are included to reflect the gradual harmonization provided for in the EC's Common Agricultural Policy. For major exporters, the unusually high response suggested by the supply coefficient at lower levels of total resource use reflects policy actions to withhold area from production. In contrast, the low response indicated at high levels of resource use reflects slowed producer response in an open-market situation. Consequently, many of the coefficients in the over 900 equations of GOL reflect a combination of economic variables as well as policy constraints. Thus, meaningful use and interpretation of output of the model require an understanding of the implications intended.

ALTERNATIVES PRESENTED BY THE MODEL

The GOL model has been used both to assist analysis of broad alternative futures and to assist answering specific questions. The broad alternatives usually specify income growth or technological progress as being faster or slower than expected. Or they specify general changes in import restrictions. The broad alternatives are implemented by changing, uniformly, the income or population growth rates for the developed or developing regions and by changing specific model parameters that represent, for example, import levies. Some specific questions for which runs have been developed are these:

- What would happen to production, consumption, and trade if the U.S. export price of grains were fixed?
- What would result if Brazil added substantially to its oilseed area?

Answering such questions often requires adding additional equations and variables to the model, and, usually, careful consideration of the overall model structure.

STATUS OF MODELING EFFORT

The modeling efforts outlined here are in varying stages of development with regard to:

- Testing the mathematical feasibility of quantifying the interaction of economic, technical, and policy considerations.
- Developing computer capabilities to generate and present alternative futures at reasonable costs
- Exploring the issue of short-term forecasts versus long-run projections
- Establishing linkages to other models that have different aggregations and
- Retaining GOL's stochastic properties and assessing the probabilities of alternative futures.

The GOL model moves beyond previous ERS efforts to developing an ongoing detailed world model with several commodities, one sufficiently flexible to project alternative futures that are internally consistent within and between alternatives. The computer program consists of three parts: (1) a matrix generator to facilitate data input, (2) the MPS-3 programming system for obtaining the solution, and (3) a report writer for presenting results.[5]

[5] Roger Strickland helped develop the matrix generator (*17, 25*). Current costs for the usual run at USDA's Washington Computer Center are about $20 for the matrix generator, $20 for the solution, and $3 for a printout of the results. Output includes about 30 tables containing data on supply and distribution, prices, per capita production and consumption, and growth rates; and special summary tables.

Level of Detail

GOL's main strength is its level of commodity, regional, and price detail. It provides for resource competition across the crop sector and demand competition among different crops for food and feed use. GOL also incorporates physical input-output rates in the feed-livestock sector and in the crop sector of the developing countries. The regional detail differentiates producing and consuming regions as well as regions at different levels of economic growth and income levels. The model's supply, demand, and trade price detail allows policy flexibility on production and marketing strategies. While the detail incorporated into GOL leads to a number of computational problems, exclusion of any of the model's commodity, region, or price components could reduce cross-commodity and cross-region competition and differentiation.

Limitations

A number of programming limitations affect GOL. The endogenous (simultaneous) part of the model is limited to linear equations. At low price levels, such equations. tend to generate very low price response. Nonlinearities are handled by specific changes to the input file; that is, by compensating through coefficient adjustments. Also, the current version of the model does not include a trade matrix or an objective function. Though set in a linear programming (LP) framework, GOL has a square matrix, in which the solution algorithm is used as a matrix inverter. A transportation and transfer matrix and objective function could be added at some later date.

GOL is a static equilibrium model. Though this characteristic may be appropriate for long-term projections, it is not satisfactory for short-term and, possibly, intermediate-term forecasting. Equilibrium point estimates can be made for different projected time periods, but estimates for each period are independent of estimates for any other period. A more ideal system would project a dynamic sequence of estimates, beginning from some current level because some variables (such as stock levels and production shortfalls) are critical in the short and intermediate term. Other variables (such as population and those factors affecting the resource base) would predominate in the longer run. The modeling system should permit testing the impact of a disturbance, such as a production shortfall, at any future point in time in relation to the projected situation at the point of disturbance. Work in this area, taking into account trade flows, is being pursued by Takayama in Illinois and, to a lesser extent, by Johnson at North Carolina State. ERS economists, particularly Kost and Schwartz, are also working to link long-range projections with short-term forecasting in the international area.

Future Refinements Under Consideration

Three methods are currently being considered to solve GOL's programming limitations. First, the number of variables could be reduced by combining some regions or by eliminating the "accounting" variables; that is, those variables which appear only in their definitional equations. Second, the GOL model could be taken out of the LP environment, as other solution algorithms may be preferable. Third, pre- and post-optimization routines could be added to the computational system. For example, it might be desirable to divide the model into subsectors, as explained below. This procedure would reduce the number of variables and equations that would be needed for the LP (or quadratic programming) optimization routine.

Another area needing more study is that of linkages with other international models, whether in terms of inputs or outputs. Linkage questions also arise from problems of aggregation or disaggregation. Factors such as income link the GOL model to a country or region's general economy. However, no provision is made for feedback, which could be important in those developing countries where agriculture is the major sector in the economy. A multicommodity model, in some instances, should also be linked to more global trade models to reflect changes in foreign exchange positions and their impacts on commodity trade. Linkage to a more detailed single-commodity model may also be desirable. Also important is tying the GOL model output into the more detailed ERS core projections system for the United States and providing for cross-model interaction. More formal interaction is needed here.

In the current version of GOL, grains were emphasized, and livestock products received less than full coverage. As more information becomes available, particularly for the developing countries, the livestock sector could be enlarged. This change could require creating separate detailed submodels which could be linked to a more aggregate type of GOL model. Subsector models of this type could be integrated into a collapsed version of GOL in which only the excess supply and demand functions (trade) would be solved simultaneously.

Very little formal analysis has been done to evaluate the stochastic properties and assess the probabilities of alternative GOL projections. This work would require assessing the probabilities of the assumptions as well as the stochastic properties of the model structure. Projecting backward into history might provide some clues. However, projections of alternative futures often involve changes in structures that have no historical record. Further analytical effort is needed to document those parts of the model with stochastic properties and those without them, so that the relative probabilities of the projections can be realistically assessed.

WORLD GRAIN-OILSEEDS-LIVESTOCK ECONOMY, 1985: ASSUMPTIONS

Each of the alternative projections of the GOL model has involved general as well as specific assumptions. Several of them, such as the absence both of major wars

and natural disasters, are common to all the alternatives. Incorporating a natural disaster or world war assumption would completely overshadow the relationships within the agricultural sector or the general economy, and it would shape projections to fit exogenous political or humanitarian considerations. The areas covered in some of the basic assumptions are outlined below.

General Assumptions

Population. Population growth is a key variant in demand growth for agricultural products. The United Nations median variant population growth rates, as assessed in 1974 and modified within ERS to reflect subsequent developments, were used for each region. An exception was the United States, for which population is projected according to series III figures from the U.S. Department of Commerce. From 1969-71 through 1985, population is expected to increase 0.8 percent annually in the developed world and 2.7 percent annually in the developing market economies.

Income. Income is another key variant in demand growth for agricultural products. While population may be the single most important demand factor in the developing countries, income is the most significant contributor in the developed nations.

USDA projections use real per capita private consumption expenditure (PCE) or, when PCE data are not available, either gross domestic product or net material product as demand shifters. The basic income projections used in GOL are the projected "trend" income values from the Food and Agriculture Organization's (FAO) 1974 *Assessment*. For the developing countries, FAO rates to 1985 are above the trend levels of the last decade and a half. GOL's alternative projections are based largely on adjustments to those basic income growth rates. In all cases, however, income and price inputs are measured in constant currency units with a 1970 base.

Specific Assumptions

Technology and Inputs. The projections assume that technology will continue to evolve as in the recent past. The developed countries, and, to a lesser extent, the developing countries, will continue to take advantage of technological innovations. Rates of adoption, however, will generally remain limited by the relative costs of inputs, particularly the energy costs assumed to be higher for the projected period than in the past decade. More specific adoption assumptions, particularly for the developing countries, are incorporated into individual GOL alternatives.

Some analysts question whether technological improvements will permit increases in crop yields over the next decade and a half at the rates achieved over the last two decades. However, analyses of growth in grain yields in the major grain-producing regions of the world for 1965-75 fail to substantiate the contention that growth in grain yield is stagnating.

Weather Variability and Stock Change. Weather variations and stock levels are key factors affecting supply availabilities, price fluctuations, and trade levels. Production levels in any one year will be affected by long-term weather trends as well as by year-to-year fluctuations. Alternative stock policies aimed at accumulating and drawing down reserves in periods of surplus or production shortfall can either aggravate or minimize the price and consumption adjustments generated by weather fluctuations.

The GOL alternatives all assume normal weather. Small fluctuations in stocks are associated with a normal weather assumption. If weather patterns deviate substantially from the normal of the last two decades, and if shortfalls occur more often than twice a decade, substantially high production levels in the "good" years would be needed to accumulate sufficient stocks to maintain consumption in "bad" years. Given the probability of shortfalls and specific policies as to how much these would be covered from stocks and how much met by cutbacks in consumption, another GOL alternative could be projected to quantify changes in price, production, consumption and trade levels.

Policy Assumptions. The policies of the major importing countries can affect production, consumption, and trade as much as can the interactions of economic variables. Agricultural and trade policy assumptions are incorporated into the different alternatives, explicitly or implicitly, through adjustments in the coefficients. For example, the total area equation for the major exporting countries has a very responsive price coefficient to reflect the effect of open-market forces as well as likely government action to adjust area to changes in foreign and domestic supply and demand conditions.

The price and stock policies of the major exporting countries are basic to all the alternatives.[6] The major exporting countries are expected to continue their present policies of adjusting production levels and of carrying at least the minimum stocks necessary to keep the world in relative balance rather than to permit sizable surpluses and deficits to develop.

The restrictive trade and domestic agricultural production policies of the major developed importing countries other than Japan are expected to continue through 1985 in GOL's base alternatives. The countries of Western Europe in particular are assumed to maintain at least current self-sufficiency rates through continuation or modification of present food and fiber policies. It is assumed, for example, that the EC will continue to use variable levies to control the flow of imports. It is also assumed that price policies of other Western European countries will result in price levels similar to those in the

[6] Given the key U.S. role in either the export or import of all the commodities considered in GOL, the appropriate U.S. c.i.f. or f.o.b. price is used as an indicator of world supply and demand conditions.

Community. Possible changes in policy mixes are tested under different alternatives.

The longrun level of U.S. trade with the USSR, People's Republic of China, and Eastern Europe is assumed to be affected more by political than economic factors. Though no special multicommodity trade agreements have been assumed between the United States and the centrally planned countries, the levels of trade projected are in line with the quantities outlined in recent bilateral agreements.

The livestock and poultry economies starting up in most of the developing countries are not assumed to have taken off by 1985. Foot-and-mouth disease, aftosa, will continue to strongly influence trade patterns. As aftosa already exists in both Europe and South America, trade in fresh and frozen meat between these two continents will continue. And because the disease does not exist in Oceania and the United States, they will be able to export to the whole world, but they will not import fresh or frozen meat from any affected areas.

Quotas on beef imports to the United States are assumed to continue. Imports of dairy products to the United States also continue to be limited by quotas. Butter is excluded and some growth in cheese imports is permitted as demand warrants. Because of continued health regulations, other policy factors, and natural developments, fresh milk is assumed not to be traded. Primary adjustments in dairy markets between countries will occur for butter and cheese. It is assumed that their prices can be read as barometers of price pressures in the international dairy situation.

WORLD GRAIN-OILSEEDS-LIVESTOCK ECONOMY, 1985: RESULTS

Overall Conclusions

The general results common to all alternative sets of 1985 projections from GOL generated to date indicate the following:

- Continued growth in economic activity, particularly in the developed countries, would generate a strong and growing demand for meat and livestock products—under all alternatives.
- Per capita meat consumption grows under all alternatives projected; however, per capita consumption stagnates in the developing countries under the low-income growth alternative.
- In the base projection, per capita meat consumption in the commercial sector of the world meat economy is expected to rise from 72 kilograms to an annual average of 78 kilograms in 1985.
- Though expanding demand for livestock products cannot occur without growth in income, national production and trade policies may be more important than income growth in determining world demand and trade levels for meats. Policies stimulating or dampening meat consumption growth in Western Europe and Japan could alter world trade patterns directly, and they could retard or stimulate meat consumption elsewhere indirectly.
- Continuation of present policies would tend to bring high internal price policies and continued barriers to meat imports in Western Europe and Japan, including restrictions on consumption in some developed countries because of high fuel and energy costs.
- Developed countries will continue to be the major meat producers—almost two-thirds of world meat in 1985.
- In the base projection, a 44-percent increase in feed grain allocation is associated with a 36-percent rise in meat production in the developed countries; in the developing countries grain use for livestock feed grows 79 percent while meat production increases 70 percent.
- Projected higher relative feed costs will dampen expansion of meat production unless economies occur in the marketing and production structure of the livestock sector.
- If harmonization of the European Community is fully realized by 1985, the following impacts on trade patterns in meat follow:
  - —The United Kingdom is largely eliminated as an import market for third-country meat as EC members trade more and more with each other.
  - —Australia loses the United Kingdom market but enjoys largely offsetting expansion of exports to the United States, Japan, and elsewhere.
  - —Argentina's loss of the EC market is not directly compensated in the U.S. market because of the aftosa problem.
- The United States continues to be a more important market than Japan and Western Europe for meat imports; if Japan and Western Europe adopt a less restrictive approach, the traditional exporting countries would find markets more encouraging in Western Europe and Japan than in the United States.
- Over the next decade, the world can produce enough grain at reasonable prices to meet the demand of a largely cereal diet in the developing world and a moderately rising feed demand in the developing world.
- World trends in the production of individual grains are expected to continue. Wheat will account for slightly less than a third of the grain total while coarse grains are expected to increase slightly, at the expense of rice, to roughly three-fifths of the total. Approximately two-thirds of the production increase is expected to result from assumed levels of improved yields. The remaining one-third results from increases in area.
- Importing and exporting countries in the developed and centrally planned countries will continue to be

the major producers and consumers of wheat and coarse grains; rice production and consumption will remain concentrated largely in the developing countries.

- The big factor in the growth in demand for grain in the developed countries will be the feed demand generated by an expanding livestock sector.
- Substantial increases in food grain demand are expected over the next decade in the developing market economies, primarily because of an expected 2.7-percent growth in population. Total cereal consumption is projected to rise annually at 3.2 to 3.7 percent.
- The world grain balance hinges largely on the degree to which the lower income developed countries follow the feed usage patterns of the United States and the European Community. If income grows rapidly in the developing countries and it is translated into demand for livestock products, or if the medium and low-income developed countries adopt the livestock techniques of Japan, the European Community and the United States, or if both developments occur, grain prices would be pushed substantially above the base 1970 price level. But as demand for feed tightens available world grain supplies, food demand would be expected to outbid feed demand, particularly in the developing countries.

Specific Conclusions Regarding the Developing Market Economies

Based on results of GOL for all 1985 projections, certain developments are likely in the developing market economies:

- World grain production over the next decade will permit continued improvement in per capita cereal consumption in the developing market economies. Per capita consumption levels are projected to rise from 172 kilograms in the 1970 base to 185 kilograms in 1985 under the base assumptions. Per capita consumption would be as high as 202 kilograms under the high demand, high productivity alternative.
- Production of cereals in the developing market economies is projected to barely exceed the annual population growth rate of 2.7 percent. Growth in production under the high productivity alternatives, however, would average a full 1 percent above the population growth rate.
- The developing countries' import demand is projected to rise from 18 million metric tons in base period to 48 million tons in 1985 under the base alternatives and as high as 68 million tons under the high-demand alternative. Developing countries' imports could be as small as 34 million tons if these countries accelerate production by increasing inputs and adopting updated technology at the rates postulated under the high productivity alternative.

APPENDIX

Details of GOL Model in 1975

The Appendix summarizes GOL's mathematical form and presents one region's equations (pp. 96-97).

In matrix form, the model can be written as:

$$AX = D$$

where A is a coefficient matrix (square) of linear interactions, X is a vector of endogenous variables, and D is a matrix of the exogenous parts of the model.

Though the matrix A must be linear because a linear programming solution is used, matrix D has no such limitations. The form of D depends on the assumptions made with respect to the kind of impact expected from the exogenous or given variables. The impacts may take one or some combination of the following forms:

$$D = C + B(1 + R)^T$$
$$D = C + EZ$$
$$D = C + KT$$

The first assumes a compound growth rate is appropriate. B is a vector of bases to be compounded, R represents a set of growth rates for particular exogenous variables, and T is the number of years over which compounding occurs. The second form assumes linear growth in which E is the coefficient matrix and Z, a vector of exogenous variables. The third simply assumes that linear trends prevail.

In the equations, the following code is used:

Characters

First, second	country
Third, fourth	functional designations, such as supply and demand
Fifth, sixth	commodity

Demand Equations

$$C6QDB + 2.6972\ C6PDB - 1.6403\ C6PDP + .6907\ C6PDZ = 1{,}448.4 + 4{,}828[1 + .6(.03263) + .00580]^T$$

$$C6QDP - 1.994\ C6PDB + 4.528\ C6PDP - .8590\ C6PDZ = 899.3 + 4{,}997[1 + .5(.03263) + .00580]^T$$

$$C6QDZ - .5814\ C6PDB - 1.0855\ C6PDP + 2.934\ C6PDZ = 363.88 + 1{,}917[1 + 1.0(.03263) + .00580 + .005]^T$$

$$C6QDV - .0276\ C6PDB - .0392\ C6PDP + .0594\ C6PDV = -11.46 + 231[1 + .00580]^T$$

$$C6QDLM + 76.52\ C6PDLM = 7{,}881.6 + 31{,}526[1 + .2(.03263) + .00580]^T$$

$$C6QDLB + 4799\ C6PDLB = 837.91 + 1{,}197[1 + .2(.03263) + .00580]^T$$

$$C6QDLC + .7591\ C6PDLC = 1{,}099.2 + 1{,}832[1 + .5(.03263) + .00580]^T$$

$$C6QDWH + 44.46\ C6PDW = 4{,}460.2 + 22{,}300[1 - .1(.03263) + .00580]^T$$

$$C6QDCH + 21.38\ C6PDC = 1{,}964.8 + 9{,}825[1 + .1(.03263) + .00580]^T$$

$$C6QDRH + .5425\ C6PDR = 181.19 + 604[1 + .2(.03263) + .00580]^T$$

$$C6QDGF - 1.3\ C6QSB - 3.6\ C6QSP - 2.7\ C6QSZ - .25\ C6QSV - .1248\ C6QSL - 3.1\ C6QSE - 30.92\ C6PSP + 253.67\ C6PDC - 45.72\ C6PDK = -51{,}128.84 + 46{,}625[1 + .005]^T$$

$$C6QDWF - .185\ C6QDGF + 20\ C6PDW + 50\ C6PTW - 50\ C6PTC = 2{,}150.28$$

$$C6QDCF + C6QDWF - C6QDGF = 0$$

$$C6QDKF - .16\ C6QSB - .67\ C6QSP - 1.18\ C6QSZ - .0326\ C6QSL - .71\ C6QSE - 17.8\ C6PSP - 103.3\ C6PDC + 25.40\ C6PDK = -30{,}474.74 + 10{,}546[1 + .004]^T$$

Supply Equations

$$C6QSB - 2.27\ C6PSB + .8785\ C6PSP - 6.431\ C6PSL + 9.6104\ C6PDC + 4.3307\ C6PDK = -441.6 + 4{,}416[1 + .02]^T$$

$$C6QSP + 1.952\ C6PSB - 4.698\ C6PSP + 3.098\ C6PSZ + 22.028\ C6PDC + 9.926\ C6PDK = 2{,}530.9 + 5{,}091[1 + .024]^T$$

$$C6QSZ + .494\ C6PSB + .509\ C6PSP - 2.743\ C6PSZ + 8.356\ C6PDC + 5.649\ C6PDK = 768.0 + 1{,}920[1 + .044]^T$$

$$C6QSV + .0376\ C6PSB - .284\ C6PSL + .3183\ C6PDC - .0602\ C6PSV = 165.74$$

$$C6QSE = 2{,}576[1 + .00580]^T$$

$$C6QSL - 8.425\ C6PSB - 252.9\ C6PSL + 404.9\ C6PDC + 218.9\ C6PDK = -3{,}721.96 + 74{,}412[1 + .003]^T$$

$$C6QSLC = 1{,}859[1 + .5(.03263) + .010]^T$$

$$C6QSL - C6QDLM - 22.935\ C6QSLB - 7.105\ C6QSLC = 0$$

$$C6HAT - 29.05\ C6PSC = -2{,}192.7 + 21{,}925[1 - .75(.03263) + .025]^T$$

$$C6HAW - 71.32\ C6PSW + 91.67\ C6PSC - .435\ C6HAT = 347.41 - 80\ T$$

$$C6HAC + 71.32\ C6psw - 91.67\ C6PSC - .530\ C6HAT = -295.035 + 80\ T$$

$$C6HAR - .2157\ C6PSR = -38.791 + 194[1 + .003]^T$$

$$C6QSW - 81.26\ C6PSW - 3.19\ C6HAW = -1.574.99 - 63.07\ C6ZI + 875\ T$$

$$C6QSC - 156.18\ C6PSC - 3.47\ C6HAC = -3{,}932.2 - 78.59\ C6ZI + 1{,}260\ T$$

$$C6QSR - .735\ C6PSR - 3.41\ C6HAR = 65.58 - 1.983\ C6ZI + 6\ T$$

$$C6QSK = 549 + 10\ T$$

Regional Equilibrium Conditions

$$-C6QSB + C6QDB + C6QTB = 0$$

$$-C6QSP + C6QDP + C6QTP = 0$$

$$-C6QSZ + C6QDZ + C6QTZ = 0$$

$$-C6QTZ - C3QTZ = -44.0$$

$$-C6QSV + C6QDV + C6QTV = 0$$

$$-C6QSLM + C6QDLM + C6QTLM = 0$$

Regional Equilibrium Conditions (Continued)

$$- C6QSLB + C6QDLB + C6QTLB = 0$$

$$- C6QSLC + C6QDLC + C6QTLC = 0$$

$$- C6QSW + C6QDWH + C6QDWF + C6QTW = 0$$

$$- C6QSC + C6QDCH + C6QDCF + C6QTC = 0$$

$$- C6QSR + C6QDRH + C6QTR = 0$$

$$- C6QSK + C6QDKF + C6QTK = 0$$

Supply-Demand Price Equations

$$C6PSB - .7\ C6PDB = 100.9 - 200[1 + .2(.03263)]^T$$

$$C6PSP - .8\ C6PDP = 197.6 - 150[1 + .2(.03263)]^T$$

$$C6PSZ - .7\ C6PDZ = 150.7 - 150[1 + .1(.03263)]^T$$

$$C6PSV - C6PDV = 0$$

$$C6PSL - .1324\ C6PSR = - .3\ T$$

$$C6PSW - C6PDW = - 3.30$$

Demand-Supply Price Equations

$$C6PDLM - C6PSL = 0$$

$$C6PDLB - 22.935\ C6PSL = - 616.305$$

$$C6PDLC - 7.105\ C6PSL = 716.185$$

Demand-Trade Price Equations

$$C6PDB - C6PTB - C6PLB = 0 + 209[1 + .3(.03263)]^T$$

$$C6PDP - C6PTP - C6PLP = - 150.0 + 150[1 + .3(.03263)]^T$$

$$C6PDV - 1.2\ C3PTV = 0 + 134.4[1 + .3(.03263)]^T$$

$$C6PDW - C6PTW - C6PLW = - 21.82$$

$$C6PDC - C6PTC - C6PLC = - 5.63 + .3\ T$$

$$C6PDR - C6PTR - C6PLR = 2.64$$

$$C6PDK - C6PTK = 0$$

Price Equations Variable Levy

$$C6PLB + .2\ C6PTB = 159.0 + 249[1 + .3(.03263)]^T$$

$$C6PLP + .2\ C6PTP = 117.2 + 297[1 + .3(.03263)]^T$$

$$C6PLW + .2\ C6PTW = 13.04 + 45[1 + .1(.03263)]^T$$

$$C6PLC + .2\ C6PTC = 12.36 + 29[1 + .1(.03263)]^T$$

$$C6PLR + .2\ C6PTR = 30.91 + 100[1 + .1(.03263)]^T$$

Regional Price Equations

$$C3PDZ - 1.4\ C6PSZ = - 127.4 + 77.4\ DVZ + 3\ T$$

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EFFECTS OF AN EXCHANGE RATE CHANGE ON AGRICULTURAL TRADE

By William E. Kost*

A theoretical model is reviewed and used to evaluate the effects of currency devaluation or revaluation on production, consumption, trade, and price in both exporting and importing countries. The model is applied to the effects of devaluation on the agricultural sector, when supply and demand are inelastic. Based on the analysis, devaluation will have only a small impact on agricultural trade. What effect there is will be primarily on price rather than quantity.
Keywords: exchange rates, devaluation, commodity trade, export supply, import demand.

BACKGROUND

Most writers of literature on devaluation, revaluation, and exchange rate policy take a macroeconomic approach. Generally, they view exchange rate policy in the context of balance-of-payments adjustment. Currency devaluations or revaluations are considered as to their effect on total exports and imports and the impact of such changes on the balance-of-payments position of the country. For example, see Kindleberger (*5*, pp. 253-309, 569-587) for a good discussion of the Marshall-Lerner condition and the absorption theory.[1] Economists have given substantially less thought to the price and quantity effect of exchange rate policy on a particular agricultural commodity. Though discussion of economic impacts of U.S. devaluations in agricultural literature over the past few years has focused on commodity impacts, not balance-of-payments impacts, it has tended to rely on a macroeconomic theory base. This missapplication of theory has led many people to conclude that the exchange rate is an important structural variable that has been omitted from any analyses of the agricultural situation. They have also come to believe that the dollar devaluations contributed significantly to the increases in foreign demand for U.S. agricultural products (*1*; *2*, pp. 18-19; *3*, p. 2; *4*; *6*, pp. 1, 11-12; *8*, pp. 3, 7). After one has looked at the relevant microeconomic international trade theory, these conclusions are, at their worst, wrong or, at their best, quite misleading as to the magnitude of the effects we can expect in agriculture when the exchange rate changes.

The purpose of this article is to review the theoretical framework that can be used to assess the trade impact of devaluation or revaluation—on any commodity or any subsector of a country's economy. It traces the effects of changes in an exchange rate on commodity production, consumption, trade levels, and prices for any two trading partners. The theoretical model is used to analyze the possible effects of a devaluation on the agricultural sector of the two economies.

For purposes of exposition, the following simplifying conditions are assumed: (1) the model consists of a two-country world (or one country-rest of the world), (2) competitive economic systems exist in both countries so that a competitive equilibrium position will be reached, (3) a single homogeneous commodity is traded, (4) there are no transport costs, (5) no trade barriers exist, and (6) the market for the single homogeneous commodity can be specified by a single, downward-sloping demand function and a single, upward-sloping supply function for each country. Implications of relaxing these restrictions will be discussed later.

DEVALUATION

Case I: Effects of Devaluation by Exporter

Figure 1 shows the domestic supply and demand curves and equilibrium price of a given commodity for two countries. For the moment, assume that prices in both countries are in the same currency units. Use of this assumption temporarily ignores the exchange rate question.[2] Trade will take place if the price is different in the two countries. As the price rises in the exporting country, the domestic quantity supplied increases, and the domestic quantity demanded decreases, making more of the commodity available for export. Concurrently, as the price falls in the importing country, its domestic quantity demanded increases, the domestic quantity supplied decreases, and the importing country becomes more reliant on imports. Equilibrium is reached when prices are equal in the two countries and when the amount available for export from one country equals the amount the other country desires to import.

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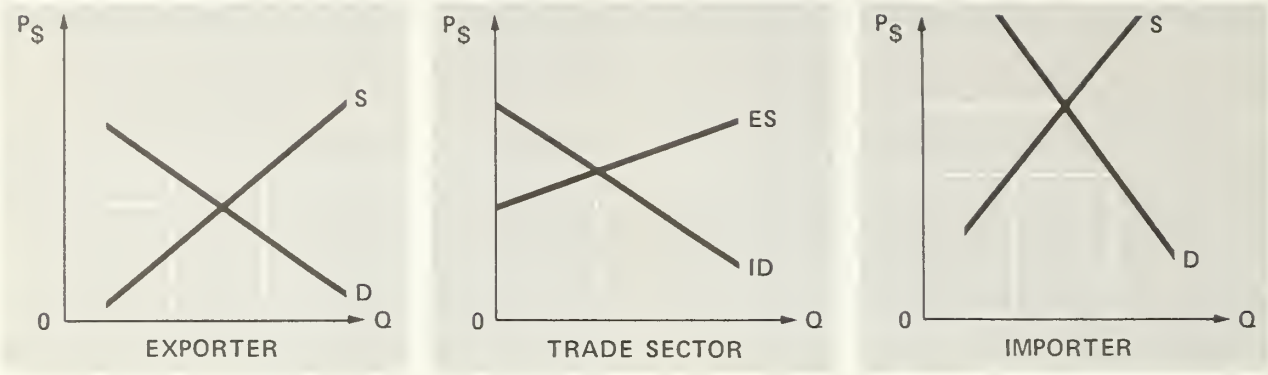
[1] Italicized numbers in parentheses refer to items in References at the end of this article.

[2] One could assume either an exchange ratio of 1:1 or that the price variables are measured in terms of a single world price.

FIGURE 1
DETERMINATION OF AN EQUILIBRIUM TRADE PATTERN



These trading relationships are summarized in the center panel of the figure. The export supply curve (ES) shows the various quantities of the commodity that will be supplied to the importing country by the exporting country at different price levels. Only when the price rises above the isolation equilibrium price will there be any of the commodity available for export. At any price above this isolation equilibrium price, the amount available for export will equal the difference between the quantity supplied and the quantity demanded.

The import demand curve (ID) shows the various quantities of the commodity that will be demanded from the exporting country by the importing country at different price levels. Only when the price falls below the isolation equilibrium price will there be any demand that cannot be satisfied from the domestic supply. At any price below this isolation equilibrium price, the amount the importing country desires to import will equal the difference between the quantity demanded and the quantity supplied.

Trade equilibrium is reached at that point where export supply equals import demand. The trade equilibrium price will be higher than the isolation equilibrium price in the exporting country and lower than the isolation equilibrium price in the importing country.[3] The point between these two prices at which the trade equilibrium price will settle depends on the relative elasticities of the export supply and import demand curves. The more elastic the export supply curve is, relative to the import demand curve, the closer the equilibrium trade price will be to the isolation equilibrium price level in the exporting country. Conversely, the more elastic the import demand curve is, relative to the export supply curve, the closer the equilibrium trade price will be to the isolation equilibrium price level in the importing country.

The elasticity of the export supply and import demand curves is a function of the underlying domestic supply and demand curves. The more elastic the domestic supply and demand curves, the more elastic the export supply and import demand curves will be. It can also be shown that the import demand curve will never be less elastic than the domestic demand curve underlying it and that the export supply curve will never be less elastic than the domestic supply curve underlying it. For a more rigorous exposition of these elasticity relationships, see the appendix.

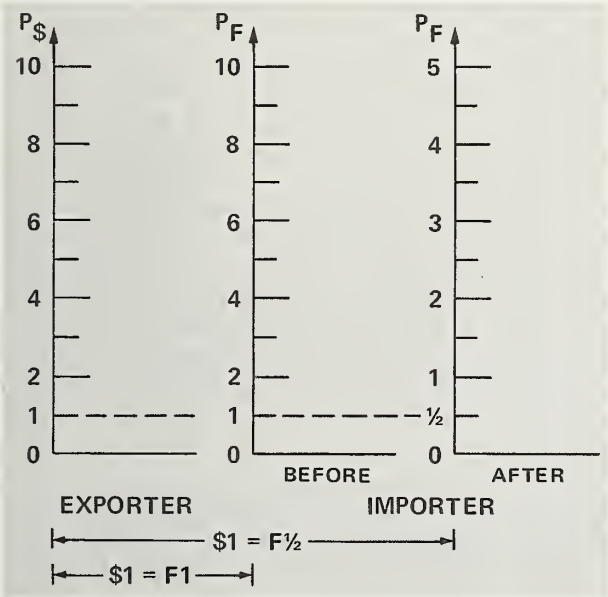
To this point, the analysis has not been based on the concept of the exchange rate. An exchange rate is the number of units of one country's currency that are exchangeable for one unit of another country's currency. An international transaction can be viewed as having two parts: (1) the purchase of the currency of the exporting country and (2) the purchase of goods from the exporting country with this currency.[4] The exchange rate can be represented in the analysis of figure 1 by comparing the scales on the vertical axes of the left- and right-hand panels of the figure. The ratio of one scale to the other represents the exchange rate between the two countries. It, however, does not explain why one currency exchanges for another at a particular rate. The price for money (the exchange rate) can be represented in the figure through an appropriate setting of the vertical scales of the left- and right-hand panels. Any fluctuation in the money market will change the relationship of the vertical scales.

[3] There are two exceptions to this statement. When the export supply curve is infinitely elastic, the trade equilibrium price will be the same as the exporting country's price in the isolation case. Conversely, when the import demand curve is infinitely elastic, the trade equilibrium price will be the same as the importing country's price in the isolation case.

[4] The importing country could purchase the goods directly with its own currency; however, somewhere along this chain of transaction, a currency transaction will occur. The important point to recognize is that any international transaction involves both a goods transaction and a currency transaction.

From the viewpoint of the exporting country, its devaluation can be expressed by changing the scale on the vertical axis of the importing country's graph. One unit of the exporter's currency will now buy less units of the importer's currency than before the devaluation occurred. Thus, in the figure, a devaluation implies a stretching out of the vertical axis on the importing country's graph. Figure 2 shows a 50-percent devaluation of the exporting country's currency; that is, from \$1=F1 to \$1=F½.

FIGURE 2
EFFECT OF 50 PERCENT DEVALUATION BY EXPORTING COUNTRY ON THE IMPORTING COUNTRY'S CURRENCY

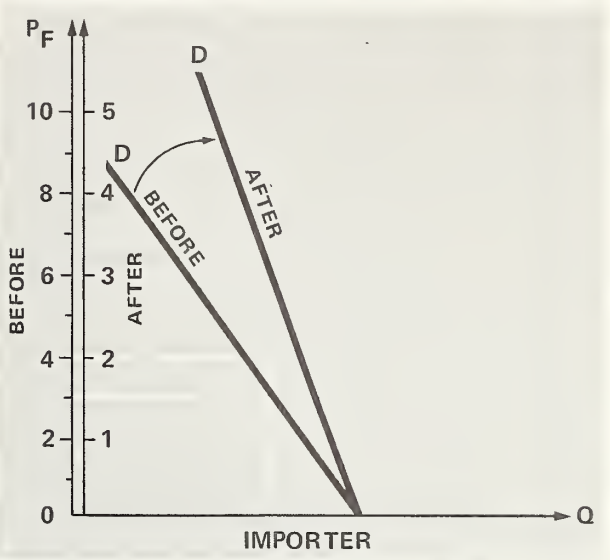


This change of the price scale (with no change in the quantity scale) will cause a "shift" in both the demand and supply curves for the importing country. Since the devaluation causes a stretching out of the price axis, the demand curve will "shift" up from its previous position. It will pivot up and to the right at the point where the original demand curve crosses the quantity axis. Since the devaluation is expressed as a percentage change, the shift in the demand curve will not be a parallel one. It will show a larger vertical shift at the higher price levels than at the lower ones (fig. 3).[5]

Devaluation will cause the supply curve to pivot at the quantity point where price equals zero. When the supply curve cuts the price axis, the whole supply curve will shift up. This shift will not be a parallel one. It represents a constant percentage change; there will be a

[5] There is a constant percentage difference between the two demand curves, however.

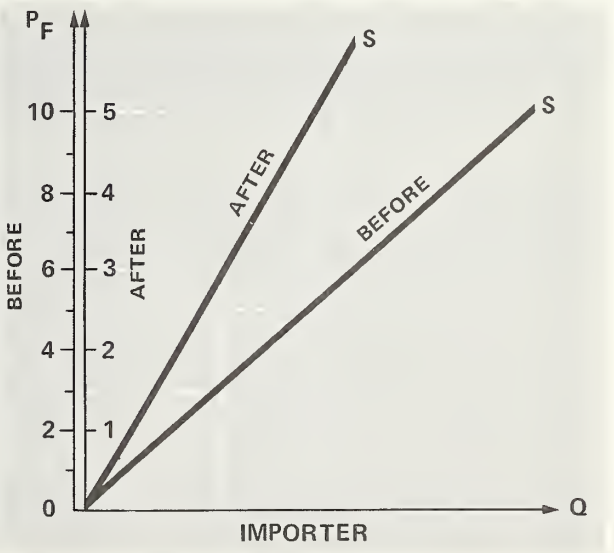
FIGURE 3
EFFECT OF DEVALUATION BY EXPORTING COUNTRY ON DEMAND OF IMPORTER



larger vertical distance between the two supply curves at the higher price levels than at the lower price levels (fig. 4).

From the point of view of the exporting country which devalues, the importing country appears to have

FIGURE 4
EFFECT OF DEVALUATION BY EXPORTING COUNTRY ON SUPPLY OF IMPORTER



simultaneously increased demand and decreased supply. What seem to be shifts in the supply and demand curves for the importing country will result in an actual increase (shift to the right) in the import demand curve (fig. 5). The rotation in the import demand curve is illustrated in the center panel of figure 5. There will be a greater vertical difference between the curves for pre-devaluation and the curves for post-devaluation import demand, the higher the trade price level. This shift also represents a constant percentage change.

A second way of looking at currency devaluation by the exporter is to consider that the importing country with any given amount of its currency can now purchase more units of the exporter's currency. Thus, the importer can, at any given price level, purchase more of the exporter's goods. Consequently, import demand for the exporter's product has increased.

A third way of viewing the devaluation is to see it as making the price of the import goods cheaper to the importing country, relative to the price of the same goods produced domestically, than before the devaluation occurred. With a cheaper relative price for the imported goods, there will be a shift away from purchases of domestic products toward imports.

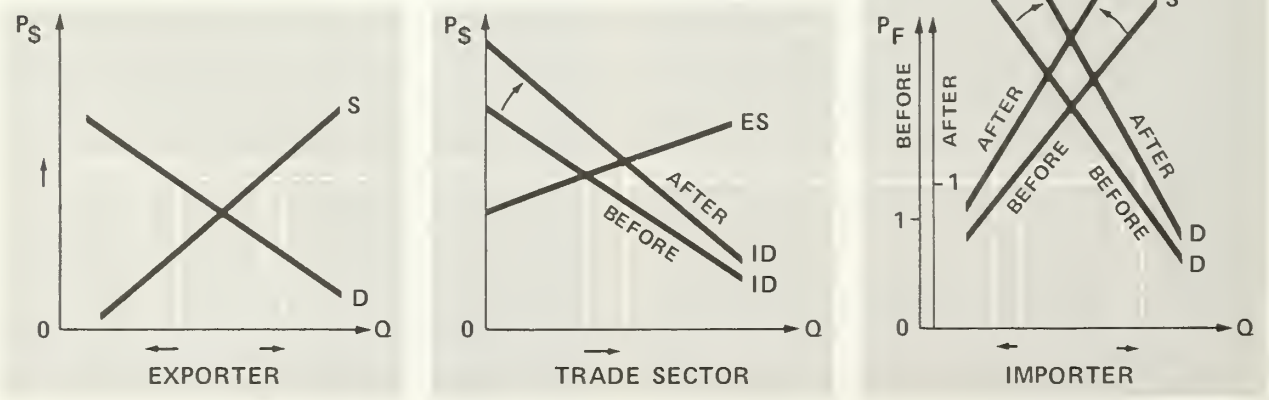
Whichever of these three ways one views a devaluation, the result is the same—an increase in import demand. Such an increase will cause an expansion in the quantity exported as well as a rise in the price (expressed in the exporter's currency units). This higher price will stimulate production in the exporting country, thus increasing the quantity supplied; and it will dampen consumption, leading to a decrease in the quantity demanded. Thus, the exporting country, receiving a higher price for its exportable goods, will produce more, consume less, and export more (fig. 5).

From the importer's viewpoint, since imports are cheaper after the devaluation, the quantity demanded will rise. With the lower price, more goods will be consumed and less will be produced domestically. This increased demand in the importing country translates into a rise in the price in the exporting country. The higher price will somewhat dampen the increased demand effect already outlined. The net effect will be to lower the price in the importing country, raise it in the exporting country, and increase the volume of trade.[6]

The apparent shift in the supply and demand curves in the importing country, and the resulting shift in the import demand curve, each equal the percentage change in the exchange rate. Thus, there is an upper limit on how much the prices and quantities traded can change. The maximum amount of the price rise for the traded goods will be by the same percentage as the amount of the devaluation. This maximum price rise will occur only when the export supply curve is perfectly inelastic and the impact of the full shift of the import demand curve is absorbed by the price change. The maximum amount of increase in the quantity traded, also the same percentage as the amount of the devaluation, will occur only if the export supply curve is perfectly elastic. Only then can the full effect of an import demand curve shift be reflected in a quantity change. Any time the export supply curve is less than perfectly elastic or less than perfectly inelastic, devaluation by an exporting country will increase both the price and quantity of its exported goods. Each of these changes, however, will represent a smaller percentage increase than that for the devaluation.

[6] It must be kept in mind that the before and after foreign demand and supply curves are based on different price axes. For a more detailed exposition of this point, see the appendix.

FIGURE 5
EFFECT OF DEVALUATION BY EXPORTING COUNTRY ON EQUILIBRIUM TRADE PATTERN FOR EXPORTS



Case II: Effects of Devaluation by Importer

A devaluation by the importing country means that it must now give up a larger amount of its currency than before to purchase the same amount of the exporting country's currency (see fig. 6 for effects). From the importer's viewpoint, the effective price it must pay for imports is raised, and quantity of imports demanded will be less. As the effective price goes up, quantity supplied domestically will rise and quantity demanded will fall. From the importer's viewpoint, it is paying a higher price for the imported product, importing less, producing more domestically, and consuming less than before the devaluation.

In terms of the exporter's currency, the decrease in imports leads to a drop in the price of the goods the country exports.[7] This reduced price leads to an increase in the quantity demanded and a decrease in the quantity supplied.

REVALUATION

Case III: Effects of Revaluation by the Exporter

Exchange rate revaluation by the exporting country means that the importing country can now purchase fewer units of the exporter's currency.[8] Thus, the importer can also buy fewer goods than before. Lowered purchase at the same price implies a decrease in import demand. Within the exporting country, both the level of exports and the price will drop. As a result, quantity consumed domestically will rise while production falls. For the importer, the higher price—in terms of the importer's currency—produces a drop in consumption, a rise in production, and a decline in imports.

Case IV: Effects of Revaluation by the Importer

Revaluation by the importing country means that the importer can now give up a smaller amount of its currency than before to purchase the same amount of the exporting country's currency.[9] Thus, price to the importer falls, and quantity imported rises as movement occurs down the import demand curve of the importing country. Such a movement results from an increase in the export supply curve. This lower price in the importing country will increase its consumption, decrease its production, and raise the level of imports. Within the exporting country, the higher price of the goods—in terms of the exporter's currency—induces a fall in consumption, a rise in production, and an increase in exports. Exports rise even with the higher price in the exporting country because the price is lower in terms of the importing country's price, not higher.

IMPLICATIONS FOR AGRICULTURAL TRADE

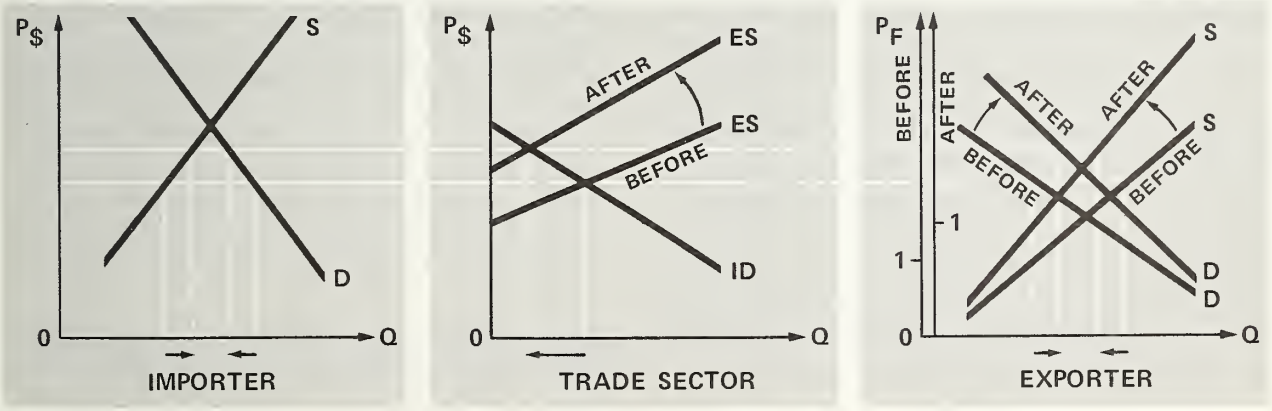
The impacts of exchange rate changes on trade and prices—for both agricultural and other commodities—depend on the magnitude of the exchange rate change

[7] The price change shown in figure 6 does represent a price decrease. See appendix.

[8] To visualize this case of revaluation, interchange the "before" and "after" labels and change the direction of the arrows in figure 5. Purchase of fewer units shrinks the price axis scale.

[9] To visualize this case of revaluation, interchange the "before" and "after" labels and change the direction of the arrows in figure 6. Purchase of fewer units shrinks the price axis scale.

FIGURE 6
EFFECT OF DEVALUATION BY IMPORTING COUNTRY ON EQUILIBRIUM TRADE PATTERN FOR IMPORTS



and the elasticities of the export supply and import demand curves. The extent of the exchange rate change determines the magnitude of the shift in the import demand curve. The elasticity of the export supply curve determines the impact of a shift in the import demand curve on the equilibrium trade price and the quantity exported. As the export supply curve becomes more elastic, the quantity traded will increase and the price rise will decrease, for any given shift in the import demand curve. This export supply elasticity depends on the domestic supply elasticity, the elasticity of demand in the exporting country, and the relative importance of the export sector.

The effect on imports of a change in the exchange rate is similar. This impact is a function of the magnitude of the exchange rate change and the elasticity of the import demand curve. The extent of the devaluation determines the amount of the shift in the export supply curve. The import demand elasticity determines the price and quantity effects resulting from the shift. The more elastic the import demand curve, the larger the quantity effect and the smaller the price effect. The import demand elasticity is a function of the domestic supply elasticity, the demand elasticity, and the relative importance of the import sector.

The elasticity of both supply and demand is very low, particularly in the short run, for U.S. agricultural products. This characteristic is especially true when we consider agricultural products relative to industrial products. Consequently, a devaluation would generate relatively larger changes in price than in quantity traded for agricultural products than for industrial goods. Also because of the extreme inelasticity of the agricultural market, it is very likely that the effect on agricultural prices will be larger than the effect on quantity. Thus, to the degree that the agricultural sector is inelastic and the industrial sector elastic, one could conclude that a devaluation would be relatively inflationary within the agricultural sector. Similarly, in the industrial sector, a devaluation would cause a relatively larger quantity impact and thus reduce unemployment more than it would in the agricultural sector. However, upper bounds to these impacts would be set by the extent of the devaluation. Generally, devaluations entail small percentage changes in the exchange rate.

One cannot determine, based on the foregoing analysis, the contribution of agricultural trade to the improvement of a country's net balance of trade (and therefore the balance of payments) when it devalues. For exports, selling more agricultural products at a higher price will improve the country's balance of trade. Changes in imports, however, will cause a deterioration. When the import demand curve is inelastic for a devaluing importer, the rise in price more than offsets the decline in quantity imported. The result is an increase in total expenditures for the goods. For a large net exporter of agricultural products, the effects on exports will probably outweigh those on imports; the net result would be some improvement in the balance of trade.

However, one cannot look to agriculture for the major contribution to improvements in the balance of payments through devaluation. The rest of the economy, where we can more reasonably expect the export supply and import demand curves to be elastic, is more likely to be the primary source of improvement. If the devaluing country's import demand curve is relatively elastic, devaluation will reduce total outlays for imports. More exports will be sold at higher prices. Thus, both the export and import sectors will contribute to improvement of the balance of payments.

Generally, each developed country has a viable trade sector other than agriculture. Not all developing countries do. Those that do not must rely on their ability to remain large net exporters of agricultural products—if devaluation is to improve their balance-of-payments position.

The reasoning to this point has assumed that a free trade world exists. To the extent that one does not, the trade impacts resulting from a devaluation will be lessened. Any barrier that insulates a domestic market from the effects of changing relative prices will restrict the amount by which the export supply and import demands curves shift. Examples of barriers would be a variable levy system like that of the European Economic Community, a quota, or a restrictive trade licensing scheme.

Another assumption used in the analysis has been that the devaluing country does not have government controlled stocks which might be used to stabilize the market. If, for example, a devaluing country wanted to stabilize domestic prices, it could, through an active stocks manipulation policy, sell supplies from the government stockpile. This increase in supply would dampen any devaluation-induced price rise. For exports, such an action would shift the export supply curve down to the right. This increased supply would hold prices down and, at the same time, make more available for the export market. The quantity exported would increase from what the level might otherwise have been. This same shift in the export supply curve would occur for imports. Here, the result would be to offset some of the shift in the export supply curve that was due to the devaluation. The quantity imported would not decline as much as otherwise. Thus, an active stocks policy could similarly moderate the devaluation effects on trade.

In summary, we can only expect a small impact on agricultural trade as a result of a change in exchange rates.[10] And what effect there is will be primarily on price rather than quantity. Any change in price or quantity traded will be limited by the percentage change in

[10] See "The Impact of Revaluation on U.S. Agricultural Exports" in this issue, for an attempt to isolate empirically the impact of exchange rate changes on agricultural exports.

the exchange rate. To the extent that the export supply and import demand curves are not perfectly elastic or perfectly inelastic and conditions exist that restrict the free flow of goods internationally, the impact on agricultural commodity trade will be less than this maximum. These conclusions suggest that recent U.S. devaluations had little effect on U.S. trade of agricultural products.

APPENDIX: Elasticity of Import Demand and Export Supply

The total demand curve for a commodity and the domestic supply curve for that commodity are defined by the following two equations:

$$Q_D = f_1(P) \text{ where } \frac{d[f_1(P)]}{dP} < 0 \text{ and}$$

$$Q_S = f_2(P) \text{ where } \frac{d[f_2(P)]}{dP} > 0$$

The quantity of the commodity that will be demanded from the exporting country by the importing country, the import demand quantity, is defined as:

$$Q_{ID} = Q_D - Q_S = f_1(P) - f_2(P)$$

$$\frac{dQ_{ID}}{dP} = \frac{d[f_1(P)]}{dP} - \frac{d[f_2(P)]}{dP}$$

The elasticity of the import demand curve is defined as:

$$\eta_{ID} = \frac{dQ_{ID}}{dP} \cdot \frac{P}{Q_{ID}} = \left[\frac{d[f_1(P)]}{dP} - \frac{d[f_2(P)]}{dP}\right] \cdot \frac{P}{Q_{ID}}$$

$$= \frac{\frac{d[f_1(P)]}{dP} \cdot P - \frac{d[f_2(P)]}{dP} \cdot P}{Q_{ID}}$$

$$= \frac{\left[\frac{d[f_1(P)]}{dP} \cdot \frac{PQ_D}{Q_D}\right] - \left[\frac{d[f_2(P)]}{dP} \cdot \frac{PQ_S}{Q_S}\right]}{Q_D - Q_S}$$

Since the elasticity of demand and the domestic elasticity of supply are defined as:

$$\eta_D = \frac{d[f_1(P)]}{dP} \cdot \frac{P}{Q_D}$$

$$\eta_S = \frac{d[f_2(P)]}{dP} \cdot \frac{P}{Q_S}$$

We can substitute these definitions into the import demand curve elasticity equation:

$$\eta_{ID} = \frac{\eta_D Q_D - \eta_S Q_S}{Q_D - Q_S}$$

This equation shows that import demand elasticity is a function of domestic demand and supply elasticity and the relative importance of the trade sector in the economy. We can see that (1) the more elastic the demand curve, the more elastic the import demand curve; (2) the more elastic the supply curve, the more elastic the import demand curve; (3) the larger the trade sector, the more inelastic the import demand curve; and (4) the import demand curve will be more elastic than the demand curve, except when there is no domestic production. When there is no output domestically, the elasticity of the import demand curve equals the elasticity of demand.

Similarly, the elasticity of the export supply curve is:

$$\eta_{ES} = \frac{\eta_S Q_S - \eta_D Q_D}{Q_S - Q_D}$$

In this equation, the elasticity of export supply appears as a function of the domestic supply elasticity, the demand elasticity and the relative importance of the trade sector in the economy. It follows that (1) the more elastic the supply curve, the more elastic the export supply curve; (2) the more elastic the demand curve, the more elastic the export supply curve; (3) the larger the trade sector, the more inelastic the export supply curve; and (4) the export supply curve will always be more elastic than the supply curve, except when there is no domestic demand.

DEVALUATION INDUCED PRICE CHANGES IN THE FOREIGN COUNTRY

Figure 7 reproduces the importer segment of figure 5. Since only the price axis changed between these "before" and "after" curves, the following relationships hold:

$P_a = P_c$, $P_d = P_b$, $P_a > P_d$, and $P_c > P_b$.

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If these statements are true, then $P_b < P_a$. Thus, devaluation by the exporting country lowers the importing country's price (defined in terms of the importing country's currency). This same type of analysis can be applied to the foreign country graphs in figure 6.

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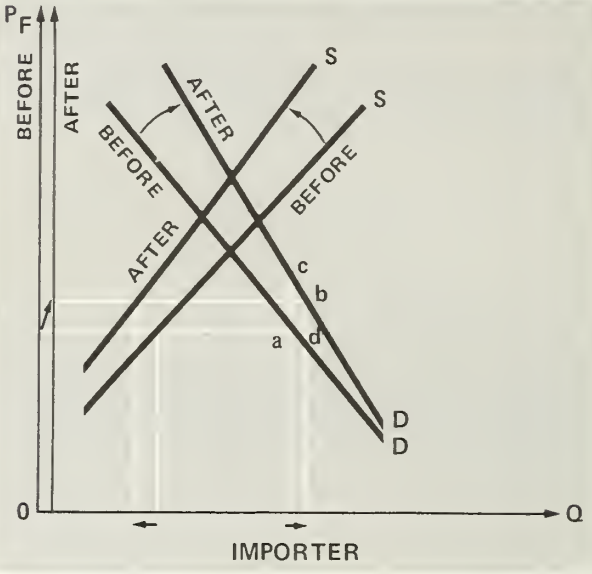
FIGURE 7
EFFECT OF DEVALUATION BY EXPORTING COUNTRY ON IMPORTING COUNTRY



THE IMPACT OF DEVALUATION ON U.S. AGRICULTURAL EXPORTS

Amalia Vellianitis-Fidas*

The 1971 and 1973 official devaluations of the U.S. dollar have often been cited as a pivotal cause for the enormous price rises in agricultural products in 1972 and 1973. This article presents two studies that test the hypothesis that exchange rate changes have a significant effect on the demand for U.S. agricultural exports. The first is a cross-sectional study of the demand for U.S. agricultural exports by major U.S. trading partners in 1971-73. The second looks at the exchange rate changes of other countries and their demand for five agricultural commodities imported from the United States as well as the world during 1954-69. Both studies support the thesis that the special circumstances present in the agricultural sector negate the effects of exchange rate changes on the demand for U.S. agricultural exports.
Keywords: Devaluation, exchange rates, agricultural demand.

Many explanations have been offered for the pressure on farm supplies which led to exceptionally large increases in farm prices in 1972-73. These include the following:

- Rising incomes in the developed countries led to increased meat consumption and therefore increased import demand for feed grains;
- Crop shortfalls in the USSR and the People's Republic of China caused unprecedented increases in world import demand and depleted grain reserves to an unprecedented low point because supplies of U.S. agricultural commodities were not able to expand rapidly in the short run;
- Two devaluations of the dollar reduced U.S. agricultural export prices initially and further increased the demand for U.S. agricultural products.

In this article I shall test the validity of only one of these explanations—the recent dollar devaluations.

The first devaluation had its immediate roots in the August 15, 1971, announcement by the United States which temporarily suspended the sale of gold for dollars. As a practical and immediate result, many countries announced that their currencies would float vis-a-vis the dollar. For most of the larger customers for U.S. agricultural exports, their currencies immediately floated upwards (that is, appreciated) vis-a-vis the dollar. In December 1971, representatives of the 10 largest members of the International Monetary Fund signed an agreement realigning their currencies. As a result, the dollar was devalued 8.57 percent vis-a-vis gold and against currencies of all other countries who chose to preserve their currencies' relationship with gold. In February 1973, after a precipitous downturn in the value of the dollar in exchange markets, the United States announced that it would unilaterally devalue the dollar again. These two devaluations by the United States broke a 27-year period of generally fixed exchange rates between the United States and its major trading partners. Thus these two actions represent a major break with past U.S. exchange rate policy.

It has usually been hypothesized that, as a result of the two devaluations of the dollar, demand for U.S. agricultural exports has increased. At the same time, supply, in the form of existing reserves or unutilized capacity, could not respond fast enough to prevent a price rise. This resulting price rise contributed to already existing world as well as U.S. inflationary pressures.

In this article, I attempt to establish whether the two devaluations significantly affected the quantity of U.S. agricultural exports. That is, was the response of U.S. trading partners significant enough to involve a measurable shift in their import demand? The intent is not to explain the level of U.S. agricultural trade or the increase in U.S. prices as a result of the two devaluations, but to measure the possible impact on the quantity demanded.

The two steps taken to test the hypothesis form the body of the article. First, cross-sectional data among countries during a fixed time period are examined to see if variations in exchange rates during this period explain the distribution of U.S. exports and imports among trading partners. Second, past exchange rate changes in other countries are examined to determine if changes in these rates explain variations in imports over time, both from the world and the United States. Finally, implications are drawn for agricultural trade from exchange rate theory.

A CROSS-SECTIONAL ANALYSIS OF TWO U.S. DEVALUATIONS

The method used in this cross-sectional analysis was ordinary least squares regression with a stepwise procedure[1] of eight variables for two commodities (wheat and

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[1] The equation with the highest R^2 as well as the highest F statistic, when all independent variables were significant at the 5-percent level, was chosen as the best step equation. If this criterion could not be met, the last equation was chosen. The stepwise algorithm used starts with all the independent variables in the regression and drops out those not considered significant.

corn) and seven variables for one commodity (soybeans) across 21 different countries (15 countries for wheat, 13 for corn, and 15 for soybeans[2]). These countries imported 54, 67, and 92 percent of the U.S. exports of wheat, corn, and soybeans, respectively, in 1972.[3] Concessional sales were not included. Changes in quantity between 1971 and 1972 and between 1971 and 1973 were measured. The effect on commodity prices was not examined. To do so would be exceedingly difficult because of the task of sorting out the factors of domestic and foreign inflation and the exchange rate. Such a task would be complicated further by the fact that a devaluation can result in a rise in the general price level as well as the agricultural price level.

Selection of Independent Variables

To ascertain which factors most influenced the variability of U.S. exports in these two periods, the following independent variables, which have often been mentioned as causal factors, were specified as indices with 1971 as the base year:

- Exchange rate changes: the change in the U.S. dollar vis-a-vis the currency of each country included in the study. These were calculated from mid-1971 to mid-1972 and from mid-1971 to mid-1973. The dollar depreciated or appreciated at a different rate vis-a-vis each country's currency during this period (X_1).
- Per capita income growth: an index of increase in per capita income to current dollars in the importing countries (X_2).
- Population growth: an index of increase in population growth of the importing countries (X_3).
- Consumer price index for the economy as a whole. This variable was chosen to learn whether the overall increases in the importing country's consumer price index significantly affected the quantity of its imports as demand spilled over into the foreign sector (X_4).
- Foreign supplies: production and stocks of wheat and corn of the importing countries in the study. These supplies were summed to arrive at an index of foreign supplies. Data limitations precluded the use of this variable for soybeans (X_5).
- Expected export quantities: United States. The trend of quantities exported from the United States to these 21 countries from 1961 to 1973 1972, and 1973 were divided by actual exports for 1971 and an index calculated (X_6). This variable and variable 7 were included to detect whether agricultural exports were on-trend. Should these variables prove not to be foremost in importance, we can more readily believe that factors unique to 1972-73, as defined by the set of other variables, significantly affected exports.
- Expected export quantities: rest of the world. The trend of quantities exported from the entire world to these countries in 1961-73 was determined. The expected quantities minus those expected for the United States were divided by actual exports minus actual U.S. exports for 1971, and an index was calculated (X_7).
- Actual exported quantities: United States. The commodities imported from the rest of the world were the dependent variables, and the commodities exported from the United States became the independent variable (X_8).
- Actual imported quantities: rest of the world. The commodities exported from the United States were the dependent variables, and the commodities exported from the rest of the world became the independent variable (X_9).

These variables were regressed on the following variables: The difference in the quantities of wheat, corn, or soybeans exported from the United States between 1972 and 1971 (Y_{1i}) and between 1973 and 1971 (Y_{2i}); and, the difference in the quantities of wheat, corn, or soybeans exported from the rest of the world between 1972 and 1971 (Y_{2i}) and between 1973 and 1971 (Y_{4i}).

The choice of independent variables may appear unorthodox since some of them, particularly per capita income and population, are correlated. However, the purpose of this analysis is not to build a model explaining U.S. agricultural exports, but simply to look at the significance of one variable—the exchange rate. This variable is not correlated to any of the others. The correlations of population with per capita income and of expected U.S. exports with expected rest-of-the-world exports may have increased the R^2 somewhat. But such correlations did not affect the measure of the significance of the main variable, the exchange rate.[4]

[2] Countries used in cross-sectional analysis and commodities imported by each (W=wheat, C=corn, S=soybeans) are: Belgium-CS; Brazil-W; Canada-S; Denmark-S; France-S; Israel-S; Italy-WCS; Japan-WCS; Korea-WC; Mexico-WC; Netherlands-WCS; Norway-WCS; Portugal-WCS; Spain-WCS; Sweden-WCS; Taiwan-S; U.S.S.R.-W; United Kingdom-WCS; Venezuela-W; West Germany-WCS; and Yugoslavia-WC;

[3] Most other sizable exports of wheat were noncommercial.

[4] The problem of multicollinearity would be crucial in a model-building exercise that seeks to explain the level of U.S. agricultural trade, but it is not crucial to the present analysis. Further, the stepwise procedure eliminates one of the correlated variables without detracting from analysis of the exchange rate variable. Whether or not the exchange rate variable continues to be statistically significant or not and whether or not it is one of the first few variables to be eliminated, one can still state with certainty that this variable either is or is not important in explaining the variability of U.S. agricultural exports of wheat, corn, or soybeans from 1971 to 1973. The problem of multicollinearity should also be reduced by using first differences. Each independent variable for equations 1 and 3 is the difference between that variable's value in 1972 and its value in 1971 and, in equations 2 and 4, the difference between the value in 1973 and the value in 1971.

Analysis of Equations for Selected Commodities

Wheat. The statistical significance and explanatory power of each wheat equation for the eight independent variables together is consistently good (table 1).[5] The lowest R^2 is 72 percent while the other three are 89, 95, and 86 percent. The trend variables for U.S. and world wheat exports were the most significant while the exchange rate variable was insignificant—in all four first-step regression equations. The rest-of-the-world equations indicated the importance of population growth and of the availability of production and stocks. Again, the exchange rate variable was not significant, and it was the fifth to drop out of the stepwise procedure.

Corn. The statistical significance of all eight variables together for the four corn equations is not as good as it was for wheat, except for the rest-of-the-world equation for 1973-71 (table 2).[6] In fact, the equation for U.S. exports in 1972-71 is not quite significant at the 5-percent level. The significant variable for the U.S. equations was the change in the actual exports by the rest of the world. But though this variable is statistically significant, it is

[5] The wheat equations are:

Y_1 wheat 1972-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_9)$

Y_2 wheat 1973-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_9)$

Y_3 wheat 1972-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_8)$

Y_4 wheat 1973-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_8)$

[6] The corn equations are:

Y_1 corn 1972-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_9)$

Y_2 corn 1973-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_9)$

Y_3 corn 1972-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_8)$

Y_4 corn 1973-71 = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, \text{and } X_8)$

Table 1.--Wheat equations 1/

Dependent variable	Independent variable 2/	Constant	Exchange rate change	Per capita Y growth	Population growth	CPI or WPI	Foreign supply	Expected U.S. exports	Expected rest of world exports	Actual U.S. exports	Actual rest of world exports	R^2	F-statistic	Status of exchange rate variable
U.S. exports of wheat 1972-1971 Difference	First step	10176.33 (432515.29) 0.02	12292.90 (11051.81) 1.11	26357.25 (16270.12) 1.62	68136.32 (161252.89) 0.42	-35205.18 (21564.55) 1.63	5713.29 (11435.98) 0.50	85.84** (37.59) 2.28	-0.47* (0.16) 2.85		-0.41 (0.40) 1.03	.89	14.56	
	Best step	28233.71 (69324.94) 0.41						124.48* (12.14) 10.25	-0.60* (0.08) 7.93			.88	52.91	5th out of 8 variables to drop out; + sign throughout
	Last step	Same as best step equation												
U.S. exports of wheat 1973-1971 Difference	First step	-497091.78 764048.14 -0.65	-8345.62 (10018.95) 0.83	19074.84 (13531.64) 1.41	88735.75 (112783.92) 0.79	5418.60 (21768.90) 0.25	-3104.17 (9558.99) 0.32	205.58* (35.50) 5.79	-3.77* (0.68) 5.57			.95	33.87	
	Best step	182562.29 (130131.62) 1.41						197.71* (11.39) 17.35	-3.51* (0.28) 12.49		0.02 (0.44) 0.05	.96	151.90	5th out of 8 variables to drop out; - sign throughout
	Last step	Same as best step equation												
Rest of world exports of wheat 1972-1971 Difference	First step	-544647.17 (343857.30) -1.58	-1407.28 (11476.68) 0.12	21260.84 (16299.99) 1.30	278201.59 (105352.12) 2.64	-14876.19 (23770.58) 0.63	17978.33** (8259.53) 2.18	-41.33 (45.63) 0.91	0.08 (0.24) 0.34	-0.37 (0.36) 1.03		0.86	11.69	
	Best step	-631258.00 (214219.84) -2.95		22172.76** (11180.74) 1.98	262784.06* (83105.32) 3.16		15009.42* (6393.32) 2.35	-25.92* (9.39) 2.76		-0.44* 0.13 3.33		.89	22.81	1st out of 8 variables to drop out; - sign throughout
	Last step	67830.41 (71878.08) 0.94								-0.78 0.10 7.87		.81	61.99	
Rest of world exports of wheat 1973-1971 Difference	First step	-384784.14 (723786.39) -0.53	-3324.50 (9821.07) 0.34	-1553.22 (14613.11) 0.11	37371.97 (109927.65) 0.34	13353.49 (19761.62) 0.68	-2599.76 (8971.37) 0.29	-73.26 (79.97) 0.92	1.23 (1.49) 0.82	0.02 (0.38) 0.05		.72	5.46	
	Best step	-53261.85 (105489.96) -0.50						-73.17* (9.24) 7.92	1.27* (0.23) 5.56			.82	31.86	5th out of 8 variables to drop out; - sign throughout
	Last step	Same as best step equation												

1/ The numbers in parentheses below the regression coefficients are the standard errors of the coefficients. The 3rd number is the t-value.
2/ *Means significant at .05 level and ** means significant at .10 level.

Table 2.--Corn equations 1/

Dependent variable	Independent variable 2/	Constant	Exchange rate change	Per capita Y growth	Population growth	CPI or WPI	Foreign supply	Expected U.S. exports	Expected rest of world exports	Actual U.S. exports	Actual rest of world exports	R^2	F-statistic	Exchange rate variable
U.S. exports of corn 1972-1971 Difference	First step	11y5966.7 (86836.74) 1.39	20485.12 22854.88) 0.90	-3720.40 (28039.24) 0.13	-987165.1 (89[illegible]8) 1.45	-94.66 (44[illegible]30.[illegible]) 0.21	2[illegible].07 [illegible]8-2.44) 1.19	-249.65** (295.86 0.84	16.56 15.18) 1.09		-0.94* (0.30) 3.14	.77	5.99	
	Best step	114479.01 93006.47) 1.23									-0.56* (.07) 8.53	.86	74.40	3rd out of 8 variables to drop out + sign throughout
	Last step	Same as best step equation												
U.S. exports of corn 1973-1971 Difference	First step	322984.00 (54180.21) 0.60	-727.69 (9642.94) 0.08	1158.90 (14593.44) 0.08	116158.99 (404534.30) 0.29	-16389.37 (20409.50) 0.80	[illegible] (17039.13) 0.18	1.81 (113.97) 0.45	1.17 (11.84) 0.10		-0.64 (0.30) 2.17	.84	9.05	
	Best step	240590.11 (245078.00) 1.02			167166.70* (48212.45) 3.47	-16711.40** (11246.81) 1.49					-0.65* (0.06) 10.55	.92	48.08	1st out of 8 variables to drop out; - sign throughout
	Last step				171707.80* (50936.80)						-0.66* (.07) 10.05	.91	63.37	
Rest of world exports of corn 1972-1971 Difference	First step	152997.90 (54920.28) 2.82	28400.65 (17279.29) 1.64	-20004.02 (22432.17) 1.78	-1455533.86* (402909.12) 3.61	-13213.23 (39259.33) 0.34	39851.27* (12821.39) 3.11	-29.0 (190.29) 2.25	25.61 8.57) 2.99	0.75 (0.24) 3.11		.93	21.90	
	Best step	1041653.63 (331569.20) 3.14			-1444728.18* (472094.62) 3.06		35199.00** (14722.56) 2.39	-396.20** (217.78) 1.82	27.18* (9.94) 2.74	-0.89* (0.27) 3.31		.91	24.15	3rd out of 8 variables to drop out; - sign throughout
	Last step	116466.24 (160780.81) .72								-1.55* (.81) 8.63		.86	74.40	
Rest of world exports of corn 1973-1971 Difference	First step	645990.76 (561887.62) 1.15	-2093.23 (11005.48) 0.19	-9026.78 (16111.68) 0.56	-468471.23 (405394.89) 1.16	-732.48 (25193.48) 0.03	20185.62 (16800.43) 1.20	-75.64 (128.45) 0.59	17.82 (10.25) 1.74			.88	12.24	
	Best step	144526.85 (120982.69) 1.19							6.35* (1.67) 3.78	-1.27*		.92	72.73	2nd out of 8 variables to drop out, - sign throughout
	Last step	Same as best step equation												

1/ The numbers in parentheses below the regression coefficients are the standard errors of the coefficients. The 3rd number is the t-value.
2/ * Means significant at .05 level and ** means significant at .10 level.

not satisfactory as to the expected theoretical effects. Since it was positive, the implication is that exports from the rest of the world and from the United States move in the same direction. The exchange rate variable was not important. For the rest-of-the-world equations, actual U.S. corn exports were consistently significant at 5- or 10-percent levels. Expected trends were also important for the 1972-71 equations. The exchange rate variable was not statistically significant in the first-step equation, and it was the third to drop out of the stepwise procedure.

Soybeans. The explanatory power of the seven variables was markedly poor for all soybean equations except U.S. exports in 1972-71 (table 3).[7] There, the exchange rate variable was the second explanatory variable to drop out in the stepwise procedure, and its sign (+) was inconsistent theoretically. The best equation in the stepwise procedure also indicated that, as world exports of soybeans moved, both in trends and actual behavior, so did U.S. soybeans.

Soybeans face many competing commodities, such as cottonseeds, flaxseed, anchovies, and, where countries lack crushing facilities, soybean oil and meal and other vegetable oils. However, because soybeans and some of these other commodities are produced in very few countries, few countries bother to keep any production and stock figures on these commodities. It is apparent, however, that the cross-elasticities for these commodities would affect demand for soybeans. Thus, production and stock figures were not included in the soybean equations, which explain why in these equations, the independent variables had such little significance and explanatory power. Nevertheless, the equations indicate the unimportance of the exchange rate variables.

Implications

Based on results of the equations presented, certain statements can be made. For the change in quantities exported for 1972 from 1971 and for 1973 from 1971, almost none of the variation in imports and exports among trading partners can be explained by the variation in exchange rates. The United States did not export relatively more or less to countries whose currencies had changed most against the dollar. At the same time, as a

[7] The soybean equations are:

Y_1 soybeans = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7$, and $X_9)$ 1972-71

Y_2 soybeans = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7$, and $X_9)$ 1973-71

Y_3 soybeans = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7$, and $X_8)$ 1972-71

Y_4 soybeans = $f(X_1, X_2, X_3, X_4, X_5, X_6, X_7$, and $X_8)$ 1973-71

Table 3.--Soybean equations 1/

Dependent variable	Independent variable	Constant	Exchange rate change	Per capita Y growth	Population growth	CPI or WPI	Foreign supply	Expected U.S. exports	Expected rest of world exports	Actual U.S. exports	Actual rest of world exports	R^2	F-statistic	Status of exchange rate variable
U.S. exports of soybeans 1972-1971 Difference	First step	-97265.71 (116115.21) -0.84	2567.16 (3044.82) .84	26513.64* (5193.00) 5.11	18799.67 (32091.29) 0.59	-11698.33 (11794.98) 0.99		6256.25 (3534.28) 1.77	-0.63** (0.19) 3.35		-0.66 (0.25) 2.61	.77	7.68	
	Best step	-128621.89 (37987.31) -3.39		28768.27 (-0.67) -0.80					-0.67* (0.18) 3.69		-0.80* (0.20) 3.98	.76	16.17	2nd out of 7 variables to drop out; + sign throughout
	Last step	Same as best step equation												
U.S. exports of soybeans 1973-1971 Difference	First step	166163.19 (357881.93) .46	7468.85 (5919.36) 1.26	10332.97 (12062.79) .86	36053.58 (57897.43) .62	-11322.37 (15472.17) .73		2151.72 (7122.04) .30	-0.93 (.82) 1.13		-0.38 (1.38) .27	-0.21	.65	
	Best step	135436.04 (80008.02) 1.69	4652.31 (4081.56) 1.14									.02	1.30	7th out of 7 variables to drop out; + sign throughout
	Last step	Same as best step equation												
Rest of world exports of soybeans Difference	First step	-173906.79 (112388.28) -1.55	-1677.83 (3356.78) .50	20373.96 (9288.47) 2.19	29559.89 (3312.42) .89	2832.49 (13422.87) .21		4567.54 (4205.15) 1.09	-0.45 (0.28) 1.60	-0.75 (0.29) 2.61		.37	2.16	
	Best step	-87989.72 (44607.21) -1.97		22095.86* (6839.98) 3.23					-0.51* (0.21) 2.47	-0.73* (0.18) 3.98				2nd out of 7 variables to drop out; - sign throughout
	Last step	Same as best step equation												
Rest of world exports of soybeans 1973-1971 Difference	First step	-32629.92 (98443.30) -0.33	-1531.13 (1694.58) 0.90	5312.58 (2820.28) 1.88	10490.57 (15749.40) 0.67	2261.35 (4299.15) 0.53		-2284.14 (1756.63) 1.30	-0.32 (0.21) 1.53	-0.03 (0.10) 0.27		.21	1.52	
	Best step	24128.35 (46463.57)	-1517.53 (1232.99) 1.23	5497.81* (2268.55) 2.42				-2535.05 (1511.75) 1.68	-0.30 (0.17) 1.73			.38	3.11	
	Last step	18713.80 (42281.90) 0.44		3606.53 (2636.79) 1.37								.06	1.87	

1/ The number in parentheses below the regression coefficients are the standard errors of the coefficients. The 3rd number is the t-value.
2/ * Means significant at .05 level and ** means significant at .10 level.

check on these results, the equations for exports from the world minus the U.S. share also indicate that the change in the U.S. exchange rate neither positively nor negatively affected exports from the rest of the world to the countries studied.

Can any inferences be drawn from these results to explain the changes in the value of U.S. exports during this same time? Value consists of quantity and price together. U.S. wheat prices stayed noticeably stable from January 1971, through the August 1971 announcement that the dollar would be allowed to float, until July 1972, when they began a precipitous rise. The recorded U.S. Gulf port export price per bushel of hard winter wheat rose from $1.76 in July 1972 to $2.95 in July 1973; by the end of 1973, it had risen to $5.44 per bushel. Soybean prices were equally stable until November 1972, when they also began to rise. Corn prices generally moved downward from January 1971 to October 1971, stabilized for the next 12 months and started to rise in September/November 1972 from about $1.50 per bushel. They continued to rise in 1973, reaching $2.83 per bushel by mid-December. Even allowing for a 3- or a 6-month lag, these enormous price rises suggest that neither the August 1971 nor February 1973 devaluations were instrumental in raising the domestic prices of these commodities. The rise in these prices was much greater than that of either or both official U.S. devaluations.

TIME SERIES ANALYSIS OF EXCHANGE RATE CHANGES IN SELECTED COUNTRIES

Did changes in exchange rates explain variations in imports and exports over time? The U.S. devaluations represent only one case study in one country. To determine whether the U.S. devaluations represented a special case, another analysis was made concerning exchange rate changes in other countries. The analysis measured the impact of exchange rate changes on other countries' agricultural imports from the United States and the world.

Time Period and Selection of Countries

The study period, 1960 to mid-1969, was chosen because exchange rates were generally stable; one country's devaluation or revaluation was not followed by retaliatory or "tied" devaluations or revaluations. The one exception was the pound sterling devaluation in 1967, which was followed by devaluations throughout much of the area where sterling is used. The period selected also represented one of stable currency relationships between the United States and its major trading partners.

The 20 countries selected had devalued or revalued their currencies at least once during 1960-69 (table 4). Of these countries 17 had devalued or revalued once,

Table 4.—Devaluations and revaluations vis-a-vis U.S. dollar, from January 1, 1960 to June 30, 1969, selected countries

Country	Date of devaluation	Percentage change[a]
Iceland	2/22/60	-57
	8/4/61	-11
	11/27/67	-25
	11/12/68	-35
Turkey	8/20/60	-69
Germany	3/6/61	+5
Netherlands	3/7/61	+5
Ecuador	7/14/61	-17
Costa Rica	9/3/61	-15
Israel	2/9/62	-40
	11/19/67	-14
Canada[b]	5/2/62	+2
Ghana	7/19/65	-58
	2/23/67	+20
	7/8/67	-30
Yugoslavia	7/26/65	-76
Philippines	11/8/65	-49
Finland	10/12/67	-24
Ireland	11/18/67	-14
United Kingdom	11/18/67	-14
Cyprus	11/20/67	-14
New Zealand	11/20/67	-19
Spain	11/20/67	-14
Denmark	11/21/67	-8
Jamaica	11/21/67	-14
	9/8/69	-50
Trinidad and Tobago	11/22/67	-14

[a] + = Revaluation vis-a-vis U.S. dollar.
- = Devaluation vis-a-vis U.S. dollar.
[b] From September 30, 1950 to May 1, 1962, no par value was agreed on with the International Monetary Fund.

two devalued twice, one devalued three times, and one devalued four times. None of these countries had multiple or floating exchange rate systems during this time nor were the majority of their agricultural imports from U.S. concessional sales.

Regressions were run on U.S. exports (by value and quantity) to these 20 countries for five commodities from 1954 to 1969. The five commodities—wheat, corn, cotton, tobacco, and oilseeds—together accounted for an average 55 percent of all U.S. agricultural exports in the last 5 years (1965-69) of the period studied. Regressions were also run on imports of these same five commodities from the world to these countries. Exceptions to this procedure occurred when any country did not import significant amounts of a particular commodity, which meant that no trade data were recorded for that commodity for that country. Time served as a simple proxy for income, population, and any other structural variables. The year of the devaluation or revaluation and each succeeding year was specified by a dummy variable value of one, unless the change occurred in the last half of the year. Any change during July-December was recorded for the next year. For years before an exchange rate change, the dummy variable was defined as zero. A separate dummy variable was included for each change in the exchange rate.

Initial Results

For each commodity, four regressions were run: (1) quantity of U.S. exports[8], (2) value of U.S. exports, (3) quantity of imports from the world, and (4) value of imports from the world. Each of the four was regressed on time and in the dummy variable.

Since each equation represents exports of one commodity to one country, results cannot be misinterpreted although wide variation existed in the amount of exchange rates changes between countries. The purpose of this analysis was the same as that of the cross-sectional analysis. That is, to determine whether a change in the exchange rate had a statistically significant effect on a country's imports and on U.S. exports of agricultural commodities. No effort was made to determine if those countries experiencing a relatively smaller percentage change in their exchange rates were affected more than those experiencing a larger percentage change. The emphasis was not on determining the degree of impact, simply to find if there was an impact.

Table 5 summarizes essential information for each commodity. The most noticeable indicator is the generally low R^2 for most commodities for most equations. This behavior suggests that time and a change in the exchange rate explained very little of the variability in quantity or in value—of U.S. exports or world imports—of these commodities. At the same time, the average F statistic for each commodity for each country equation was significant, indicating that for many countries the explanatory power of both independent variables was good. Finally, the average *t*-statistic for almost all commodities, by quantity or by value, from the United States or from the world, falls below the acceptable 5-percent level. Exceptions include some of the corn and cotton equations.

Results Summarized Through Two Tests

To summarize results of each individual country equation, two kinds of nonparametric tests were conducted. The first (table 6), involving signs, was used to test the hypothesis, at the 5-percent level, that the majority of countries for any one equation did not have

[8] Exports to countries from the United States are differentiated from imports from the world to these countries because of data availability. Export data (f.o.b.) are from the U.S. Department of Agriculture, while import data (c.i.f.) are reported by countries to the Food and Agricultural Organization of the United Nations.

Table 5.--Summary of Test Statistics of Time Series Analysis

Test Statistic / Equation	Wheat R^2	Wheat F-test	Wheat t-statistic only first devaluation	Wheat t-statistic all devaluation	Corn R^2	Corn F-test	Corn t-statistic only first devaluation	Corn t-statistic all devaluations
	(1) Quantity of imports from World				(1) Quantity of imports from World			
N	18	18	18	.24	14	14	14	20
$\bar{X}$ 1/	.41	7.58	1.31	1.27	.74	30.60	1.25	1.77
S.D. 1/	.29	11.8	1.27	1.43	.32	35.35	.92	1.50
	(2) Value of imports from World				(2) Value of imports from World			
N	18	18	18	24	14	14	14	20
$\bar{X}$	.44	6.78	1.30	1.34	.68	24.35	1.05	1.36
S.D.	.26	7.60	1.28	1.23	.33	27.50	.82	1.17
	(3) Quantity of exports from U.S.				(3) Quantity of exports from U.S.			
N	19	19	19	25	15	15	15	
$\bar{X}$	.33	5.62	.93	1.17	.52	16.97	1.78	
S.D.	.27	11.67	.88	2.09	.36	21.30	1.13	
	(4) Value of exports from U.S.				(4) Value of exports from U.S.			
N	19	19	19	24	15	15	15	16
$\bar{X}$	.32	3.66	.96	.94	.56	16.98	1.81	2.04
S.D.	.22	4.25	.89	1.41	.38	15.40	1.45	1.35
	Tobacco				Oilseeds			
	(1) Quantity of imports from World				(1) Quantity of imports from World			
N	17	17	17	18	16	16	16	17
$\bar{X}$	.57	16.07	1.36	1.30	.45	4.49	1.28	1.29
S.D.	.27	26.20	1.31	1.29	.24	4.30	.84	.80
	(2) Value of imports from World				(2) Value of imports from World			
N	17	17	17	17	15	15	15	16
$\bar{X}$	.53	13.88	1.41	1.38	.57	13.87	1.29	1.37
S.D.	.33	14.48	.32	.96	.33	20.02	1.00	1.03
	(3) Quantity of exports from U.S.				(3) Quantity of exports from U.S.			
N	18	18	18	22	9	9	9	10
$\bar{X}$	.42	7.86	1.33	1.33	.55	19.33	1.47	1.40
S.D.	.30	9.27	.78	1.04	.35	29.00	1.03	.99
	(4) Value of exports from U.S.				(4) Value of exports from U.S.			
N	18	18	18	22	9	9	9	10
$\bar{X}$	.46	13.57	1.30	1.34	.63	24.71	1.20	1.19
S.D.	.31	22.57	.84	1.20	.39	25.50	.73	.69
	Cotton							
	(1) Quantity of imports from World							
N	16	16	16	17				
$\bar{X}$	.49	9.96	1.82	1.81				
S.D.	.44	10.5	1.70	2.03				
	(2) Value of imports from World							
N	16	16	16	17				
$\bar{X}$	.48	7.54	1.28	1.31				
S.D.	.15	7.45	.88	.85				
	(3) Quantity of exports from U.S.							
N	9	9	9	10				
$\bar{X}$	.41	4.61	.65	.65				
S.D.	.23	3.30	.39	.33				
	(4) Value of exports from U.S.							
N	9	9	9					
$\bar{X}$	.39	4.41	.48					
S.D.	.23	3.79	.11					

1/ The mean for each test statistic was calculated by taking the test statistic(s) for each country's equation and dividing by the number of countries (or number of exchange rate changes). The standard deviation is the deviation of each test statistic about the mean value of the test statistic.

significant *t*-statistics for the exchange rate dummy variable. The first set of exchange rate changes per country was counted as observations. In only one test out of forty was the null hypothesis rejected, which indicates that there were enough acceptable *t*-statistics only in this one instance. The case in question was the value of tobacco imported from the world, when all exchange rate changes per country were counted. Quite possibly, tobacco, a nonfood item and, to some degree, a luxury item, would exhibit a higher inelasticity of demand than would the other commodities. Since quantity did not vary significantly but value did, it seems likely that the exchange rate change did affect price. With this exception, test results indicated that the majority of countries importing these commodities did not significantly change the level of their trade from the United States or from the world after they had changed their exchange rate.

The results of the next test are more difficult to interpret and appear more ambiguous. For the commodities, two at a time for each of the same four equations as in the previous test, their *t*-statistics were ranked for a U-test (table 7). The results indicate whether the two samples had different distributions. Coupling this information with that in table 5, we can draw some inferences as to which commodities were more likely to be affected by the exchange rate variable.

For commodities imported from the world, by quantity, equation (1), imports of cotton seemed more likely to be affected by the exchange rate variable. The average *t*-statistic for the exchange rate variable was also highest

Table 6.—Sign tests of hypothesis that the majority of countries selected did not have significant *t*-statistics for devaluation or revaluation variables

	Wheat: 1st exchange rate changes	Wheat: all exchange rate changes	Corn: 1st exchange rate changes	Corn: all exchange rate changes	Tobacco: 1st exchange rate changes	Tobacco: all exchange rate changes	Oilseeds: 1st exchange rate changes	Oilseeds: all exchange rate changes	Cotton: 1st exchange rate changes	Cotton: all exchange rate changes
	(1) Quantity of Imports from World									
Total number of devaluation or revaluation variables	18	24	14	20	17	18	16	17	16	17
Number of plus signs[a]	7A	9A	3A	7A	6A	6A	3A	3A	7A	7A
Number of minus signs[a]	11	15	11	13	11	12	13	14	9	10
	(2) Value of Imports from World									
Total number of devaluation or revaluation variables	18	24	14	20	17	19	15	16	16	17
Number of plus signs	4A	6A	2A	6A	12A	14R	3A	4A	5A	6A
Number of minus signs	14	18	12	14	5	5	12	12	11	11
	(3) Quantity of U.S. Exports									
Total number of devaluation or revaluation variables	19	25	15	15	18	22	9	10	9	10
Number of plus signs	3A	4A	7A	7A	6A	7A	2A	2A	1A	1A
Number of minus signs	16	21	8	8	12	15	7	8	8	9
	(4) Value of U.S. Exports									
Total number of devaluation or revaluation variables	19	25	15	16	18	22	9	10	9	9
Number of plus signs	3A	4A	6A	7A	6A	7A	1A	1A	0A	0A
Number of minus signs	16	21	9	9	12	15	8	9	9	9

A = Accept null hypothesis.
R = Reject null hypothesis.
[a]Number of plus signs indicates the number of exchange rate variables that were above the critical *t*-statistic while number of minus signs indicates the number of exchange rate variables that were not above the critical *t*-statistic at the .05 level.

for cotton. For equation (2), the results were somewhat different, but wheat seemed less affected than tobacco, oilseeds, or cotton by the exchange rate variable. Equations (1) and (2) also suggested fewer instances of one commodity sample being from a different population than did commodities exported from the United States.

Thus, a country's level of imports from all sources of a particular commodity apparently varies less because of exchange rate changes than when imports are from one source; here, the United States. In addition, there may have been particular factors affecting the demand for U.S. exports that were not present in imports from all the world. This situation is analogous to the supply and demand conditions faced by a single farmer versus those faced by the agricultural sector as a whole. At the same time, the results of equations (3) and (4) are, in several cases, internally contradictory. For example, more of the exchange rate *t*-statistics come closer to being significant in equation (3) for wheat rather than corn and for tobacco rather than wheat. The difference between tobacco and corn rankings, however, appears to be insignificant. The inconsistency indicates the roughness of the U-test results; thus, not too much confidence should be placed in its comparisons. The paired comparisons may indicate significant differences where none exist because of the wide variance in the observations of each sample.

Implications

Occurrence of a change in the exchange rate of a country other than the United States, whether revaluation or devaluation, did not significantly change the

Table 7.—U-Test: Comparison of commodities by type of equation, based on ranked *t*-statistics for all devaluation variables

Equation and commodity	Sample sizes compared	Z-test statistic	Difference between samples
(1) Quantity of imports from world:			
Corn/wheat	20/24	0.20	No
Corn/tobacco	20/18	1.26	No
Corn/oilseeds	20/17	1.10	No
Corn/cotton	20/17	1.52	No
Wheat/tobacco	24/18	0.77	No
Wheat/oilseeds	24/17	0.26	No
Wheat/cotton	24/17	1.05	No
Tobacco/oilseeds	18/17	1.62	No
Tobacco/*cotton	18/17	2.90	Yes
Oilseeds/*cotton	17/17	3.41	Yes
(2) Value of imports from world:			
Corn/wheat	20/17	1.71	No
Corn/tobacco	20/19	1.49	No
Corn/oilseeds	20/16	0.97	No
Corn/cotton	20/17	1.43	No
Wheat/*tobacco	17/19	3.03	Yes
Wheat/*oilseeds	17/16	7.66	Yes
Wheat/*cotton	17/17	2.09	Yes
Tobacco/oilseeds	19/16	1.39	No
Tobacco/cotton	19/17	1.66	No
Oilseeds/cotton	16/17	0.05	No
(3) Quantity of exports from United States:			
*Wheat/corn	25/15	5.14	Yes
Wheat/*tobacco	25/22	2.27	Yes
Wheat/*oilseeds	25/10	3.80	Yes
*Wheat/cotton	25/10	3.25	Yes
Corn/tobacco	15/22	1.42	No
Corn/oilseeds	15/10	0.72	No
*Corn/cotton	15/10	2.78	Yes
Tobacco/oilseeds	22/10	0.32	No
Tobacco/cotton	22/10	1.52	No
Oilseeds/*cotton	10/10	2.04	Yes
(4) Value of exports from United States:			
Wheat/*corn	25/16	3.50	Yes
Wheat/*tobacco	25/22	3.40	Yes
*Wheat/oilseeds	25/10	3.37	Yes
*Wheat/cotton	25/10	3.16	Yes
Corn/tobacco	16/22	0.84	No
Corn/oilseeds	16/10	0.71	No
*Corn/cotton	16/10	2.40	Yes
Tobacco/oilseeds	22/10	0.04	No
*Tobacco/cotton	22/10	2.00	Yes
*Oilseeds/cotton	10/10	2.40	Yes

*Indicates larger *t*-statistic rankings between paired samples.

country's level of agricultural imports from the United States or from the world.[9] Since the quantity purchased did not change much nor did the value (price times quantity), the price of these commodities—in terms of the devaluing or revaluing country's currency—did not change much either.

CONCLUSIONS

These two studies strongly imply that the change in the exchange rate of the United States, a major supplier of agricultural commodities on the world market, did not significantly affect agricultural trade. Nor did changes in exchange rates of major or minor importers have any great effect on their agricultural trade. Though these conclusions may appear somewhat surprising in terms of balance-of-payments and exchange rate theory, they actually are not when one views a particular sector, agriculture, and the conditions within that sector. For agriculture, such conditions are the inelasticities of demand and supply of agricultural commodities, particularly in the short run.

Combining exchange theory with these special conditions provides a logical explanation of why the exchange rate variable was insignificant. For further explanation, refer to William Kost's article in this issue.

Kost postulates a small shift in demand with an exchange rate change for agricultural goods. In my study, two major explanations can be offered for this small shift in demand. Naturally, the maximum amount that demand could shift would be by the amount of the devaluations. The trade-weighted exchange rates, using only countries covered in the study, indicated maximum price changes for wheat (after both devaluations) and for corn (after the second devaluation) were less than the amount of the official U.S. dollar devaluation vis-a-vis gold. This lesser change occurred because not all currencies reacted similarly to the U.S. devaluations. Some currencies floated down with the dollar, others floated down only partially, and the rest appreciated by varying amounts vis-a-vis the U.S. dollar. To the degree that the wheat, corn, or soybean trade-weighted exchange rate is less than the full amount of the U.S. devaluation vis-a-vis gold, the demand curve for exports of that commodity would shift that much less than the full amount of the U.S. devaluation vis-a-vis gold.

Secondly, institutional factors prevented the full impact of the devaluation from manifesting itself in shifts of the demands for U.S. agricultural exports, particularly in EC member countries. Provisions of the Common Agricultural Policy of the European Community keep some commodities, particularly grains, from coming

[9] For those few countries which revalued their currencies—Germany, the Netherlands, and Canada—no appreciable difference was found in the level of imports either.

into the EC at a lower price than those produced domestically. Therefore if a commodity brings a lower price in EC currencies because of the devaluation, it receives a higher EC variable levy. This action eliminates any price advantage, because the importer pays the variable levy. The result is a constant price within each EC member's currency, and, therefore, a constant price to the EC consumer. Thus, any immediate reduction caused by the devaluation in European domestic prices of U.S. exports would be negated by an increase in the variable levy. To the degree that this change occurred, the demand curve would shift by that much less than the official amount of the U.S. devaluation.

The long-term analysis indicated that the change in import quantity demanded by countries revaluing or devaluing was also quite small and perhaps even zero. For a devaluing country's currency (for example, Spain in 1967), a devaluation appears as a shift to the left of the import supply curve. This shift occurs for the same reason that the shift in the demand curve for exports occurred. Here, however, the devaluing country is the importer; a devaluation of its currency means that its currency buys fewer units of another country's currency by the amount of devaluation. In effect, the importers within the devaluing country will now be able to buy less of other countries' currencies with the same amount of money. For this to be true, a decrease in supply from all other countries occurs; that is, supply shifts to the left for the devaluing country's imports. Given that this shift occurs, two theoretical reasons can be found for the insignificant change in quantity imported that we noted for the majority of countries and commodities in the time series analysis. The shift of the import supply curve was quite small and/or demand for imports would have to be fairly inelastic. (Demand for agricultural imports is generally considered to be inelastic.)

The study also determined that the change in value due to exchange rate changes was also quite small. Thus, if the change in value and quantity were both small, as they were shown to be in the time series analysis, and value equals price times quantity, then the change in price must also be small. For this to be true, there must be only a small shift in import supply. The shift in import supply must be so small that it prevents the inelastic demand curve from producing a very great increase in price. Theoretically, the shift will be no larger than the change in the exchange rate of the devaluating or revaluing country. In addition, to the extent that the value equations are more significant than the quantity equations, it is possible to say that any measurable effect would be a price effect.

In sum, Kost's theoretical analysis indicates that one would expect only a small impact on agricultural trade because of a devaluation or revaluation. The degree to which either affects exports, imports, or both, depends principally on the degree of elasticity of the export supply and import demand curves, respectively. Particularly in the short run (the period covered by the cross-sectional analysis), the inelasticity of supply and demand in the agricultural sector suggests that exchange rate changes by countries seeking to improve their balance-of-payments position will not greatly affect the level of their agricultural trade.

Analysis presented here provides empirical support for theoretical conclusions outlined in the Kost article. Together, these analyses indicate that we must find the explanation for high U.S. agricultural prices in 1972-73 elsewhere. The U.S. devaluations were not pivotal causes.

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RESEARCH REVIEW

"In the course of foreign trade," said Thomas Mun in a letter written to his son about 1630, "there are three sorts of gain, the first is that of the Commonwealth, which may be done when the Merchant (who is the principal Agent therein) shall lose. The second is the gain of the Merchant, which he doth sometimes justly and worthily effect, although the Commonwealth be a loser. The third is the gain of the King, whereof he is ever certain, even when the Commonwealth and the Merchant shall be both losers." Gains and losses associated with foreign trade of agricultural commodities are the concern of the three articles in this issue.

The first article presents a model of the world grain-oilseed-livestock economy (GOL) used for ERS projections. The role of the GOL model in the context of other forecasting and projections activity in ERS was discussed in the April 1976 issue of AER. In this issue, the model is explained and the uses to which it is put are illustrated.

Thomas Mun went on to say, "There are three ways by which the Moneys of a Kingdom are commonly altered. The first is when the Coins in their several Denominations are made currant at more or less pounds, shillings or pence than formerly. The second is when the said Coins are altered in their weight, and yet continue currant at the former rates. The third is when the standard is either debased or enriched in the fineness of the Gold and Silver, yet the Moneys continue in their former values." And Mun concluded that "enhansing or debasing our Moneys cannot enrich the Kingdom with treasure, nor hinder the exportation thereof." Two articles in this issue reach that same conclusion with respect to agricultural trade, but the reasoning is different from Mun's. One takes a theoretical and the other an empirical approach to the problem. They both find that recent devaluations of various currencies have not enriched the devaluing nations through agricultural trade nor hindered exports.

Clark Edwards

YEARS OF STRUGGLE: THE FARM DIARY OF ELMER G. POWERS, 1931-1936

Edited by H. Roger Grant and L. Edward Purcell. The Iowa State University Press, Ames, Iowa 50010. 158 pages. 1976.

Published diaries by family farmers are rare for any period of time. The few that exist show that farmers are preoccupied with the weather and the daily routines of farm life. They also reveal a strong feeling for tradition and farming as a way of life.

Years of Struggle: The Farm Diary of Elmer G. Powers, 1931-1936 treats these facets of farm life. For example, on January 1, 1932, Powers wrote:

> Personally I still think the farm is the best place of all. The future may not look so good from a financial standpoint. However, for many folks the farm is more than a business and a place to try to accumulate wealth. It is life itself. First of all the soil, the feel of the earth. The respect they have for it. The fields. The weather and the changing seasons. All life itself comes from these several things. Then there is the plant life. The crops. The trees. The live stock and poultry and all of their young things to be cared for. The responsibility of growing the food and flesh for a distant and often unappreciative city. Just to be close to and work with nature is one of life's greatest opportunities.

Powers derived great satisfaction from the fact that his 160-acre farm had been in the family for generations and that from his "back forty" he could see the cemetery where his grandparents and other pioneers were buried.

An antiurban bias is evident in the diary. Radio advertising made him feel that the rest of the country was riding a wave of prosperity while farmers were suffering from the Depression. Powers resented President Roosevelt's 1933 request to the Congress to modify the Volstead Act to allow the sale of beer and light wines. Writing of the "beer situation," he said many people call it a "city folks" proposition. Powers told with approval of one farmer who said it reminded him of the Bible quotation: "and Jesus Beheld a City and wept over It."

A Republican, he praised an October 1932 speech of President Hoover. On the 1932 election, Powers commented: "Either the Republicans have failed to care for the affairs of the people and the Government or else they have saved a country from disaster and the people did not know it." But when the Democrats came into office, he was willing to turn to Government programs for assistance.

When the Administration changed in 1933, Powers was optimistic about what the Government could accomplish. He knew Henry A. Wallace and had faith in him. However, he expected Government programs to be synchronized so that his payments would come in time to take care of his taxes and loans. He wrote on Nov. 24, 1936: "Last year the farm was sold for taxes two days before the corn loans came out. And still they expect the farmers to put up with this kind of blundering and bungling. I am hopeful that my soil grant will come in time." He had difficulty securing loans from the Farm Credit Administration. However, he was able to buy back his farm through a loan.

Powers was particularly critical of the Civil Works Administration and Public Works Administration for paying what he considered to be high wages for short-hour days. But he praised the work of the Federal Emergency Relief Administration when free labor was provided to build new outhouses for farmers.

Powers differed from most farmers of the period because of his articulateness and his ability to type and take shorthand. The editors, H. Roger Grant and L. Edward Purcell, outline his family background as well as large sections of the diary which they deleted. They also

provide an epilogue for the years 1937-42. They selected entries for the years 1931-36 for publication because these years represented the period of greatest drama and historical significance. Their helpful footnotes provide background on Government programs and administrative problems.

Power's diary gives readers an authentic record of how one Iowa farmer survived the recurring crises of disastrously low prices, high taxes and mortgage payments, threatened foreclosures, and droughts, blizzards, and insect pests which confronted large numbers of farmers during the Depression. Of equal importance is the daily record of Powers' feelings and reactions to the crises and to the Government programs designed to solve them. Studies and autobiographies can provide much information and data but memories tend to omit and color events noted more accurately in daily records.

This diary should interest economists, historians, and political scientists because of its clear picture of family farming as a way of life. The impact of the Nation's severest depression and of Federal Government programs, followed by World War II and a technological revolution, were to change midwestern agriculture in ways neither Powers nor anyone else at the time could visualize.

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DISPERSING POPULATION: WHAT AMERICA CAN LEARN FROM EUROPE

By James L. Sundquist. Brookings Institution, Washington, D.C. 290 pages. 1975. $3.95.

James L. Sundquist has written a very readable and informative book of likely interest to social scientists, community and national decisionmakers, and others concerned with national and rural development.

He points out that population dispersal has been a widely accepted U.S. policy objective, one that had been written into law by the 1970's. He seeks to help bridge the gap between this objective and its implementation by reviewing 30 years of relevant experience of five countries—Great Britain, France, Italy, the Netherlands, and Sweden. After facing the problem of population concentration, governments in these countries had concluded that growth of their largest cities should be checked, and they enacted ambitious and comprehensive programs to achieve that end.

Population distribution or growth, says Sundquist, has two usually separable and often distinct components. One involves growth *among* regions and larger or smaller urban complexes; the other concerns growth *within* metropolitan areas, particularly the larger ones. He calls the former the *macro* aspect of population distribution and the latter, the *micro* aspect. Sundquist restricts his study to the macro aspect. Are these two aspects quite as separable and distinct as he suggests? This question is one of several evoked by the author's data.

Sundquist presents several findings, described below:

1. All five countries have laws that specify policies and programs to encourage population dispersal. Some measures are extreme, by U.S. standards.

2. Early phases of policies typically sought to increase the number and proportion of factories locating or expanding outside major cities. Financial incentives, such as preferential loans and grants, were tried. Licensing of new factories and factory expansions to restrict construction in populous areas, such as London and Paris, proved essential. Government construction of factories for rental to mobile manufacturers, sponsorship of improved community facilities and services, and provision of suitable industrial sites all were deemed helpful. The most mobile businesses were branches of large firms.

3. All the countries began with a local emphasis on distressed areas but evolved a "growth center" approach to the dispersal of manufacturing. For example, from 1966 to 1970, the French designated eight cities in as many regions outside Paris as counterweight metropolises to offset Parisian economic power.

4. Following the emphasis on factories, the countries moved, less successfully to date, toward dispersal of service industries. For example, governments licensed construction of office buildings and they have also tried to decentralize government agencies.

5. Early support for these population redistribution policies and programs was political. Major cities were deemed overcrowded and polluted, and they suffered from transportation problems. Piling up of industry, as in Greater London, was seen as a threat to national security. On the other hand, relatively depressed, more rural areas needed skilled labor, entrepreneurship, and capital from cities to spearhead new industries and so add jobs for local people. The economic rationale and supporting data for these regional policies and programs have been and remain sketchy.

6. Political support for these policies and programs has lessened in recent years, although some measures will likely be retained indefinitely. Why? A slowdown in growth, and even a population decline in some cities, has tended to increase per capita costs of public services and facilities. Local unemployment rates have risen. Cities have begun to recruit manufacturers to replace jobs lost through transfer of firms. City spokesmen are now less convinced that increased size is bad, so that emphasis may shift to more qualitative guidance of local development. Rural areas seek industry, but not polluting firms.

Were the European population modifications cited by Sundquist also economic successes? Representatives of the British motor industry, he reports, suggest that public thwarting of geographic concentration of production deemed necessary by the industry reduced efficiency which, in turn, reduced export earnings and lowered the GNP. Government witnesses were said to point to the likely greater congestion due to more concentration, so that firms' costs and social costs would have both increased. The dispute is not resolved. Apart from data paucity, other reasons (perhaps more compelling) are the need for a broader conceptual base for evaluation—either by broadening economic concepts, such as GNP, or by adding new concepts, economic or otherwise.

The book offers both perspective and heuristic value. For these European countries (and the United States as

well), the reviewer wonders, are the rate of growth of GNP and other significant national economic and social indicators favorably affected by market adjustments that help integrate local factors, including labor, into national markets? While manufacturing has been a favorite means of rural development, has its importance been overplayed? Are the relatively high-wage types of manufacturing also industries that best achieve economies of scale and agglomeration?

Without an explicit public population dispersal policy, U.S. nonmetro rates of population increase have recently outstripped metro rates. Does that fact enhance or diminish the relevance of Sundquist's report on the European experience? The author judges it will reduce U.S. political interest. For the economist, however, these changes may simply provide a new context in which to explain population patterns that are insufficiently accounted for either side of the Atlantic.

Do we have objective indexes of levels-of-living for various nonmetropolitan communities and descriptions of typical lifestyles of families at various income levels? Certainly not. On what basis, then, are migrants evaluating alternative living and job possibilities? What are the implications for rural and national development? Sundquist aptly illustrates the needed broad context for such evaluations.

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THE ECONOMIC VALUE OF HUMAN TIME OVER TIME

Over the years, the price of human time has risen greatly relative to that of the services of natural resources. Real hourly wages in the United States were more than five times as high in 1972 as they were in 1900, whereas the real price of the commodities most dependent on natural resources tended not to rise.

Why have real wages risen so much despite the more than tripling of the size of the labor force? Why has Ricardian Rent lost its economic sting? Over the past several decades, Ricardian Rent has been large, relative to wages, in low-income countries. But it has been comparatively small in countries where high incomes have been achieved. As a social, political, and economic class, landlords, in Ricardo's sense, fade away as countries attain a high level of personal income. Economic theory does not tell us why. Additionally, in low-income countries, the economic value of human time is low. But in high-income countries, wages are high.

The explanation of the rapid rise in value of human time compared with prices of natural resources is well concealed in our economic history. It is not to be found in the theory of Ricardo-Malthus, nor in Marx, nor in Keynes. Events and human behavior alter values and the stock of all types of capital. Advances in knowledge develop (1) substitutes for land (natural resources) and (2) complements for human capital.

We know more about the supply of human capital than we do about demand for it. Complementarity between human and producer capital appears to be the key to upward shifts in demand for human capital.

Economic theory, while short on explanation of the rise in the value of human time, can help us derive implications that can be tested. Three such implications and supportive data follow:

The share of national income accruing to property assets should decline. It has declined from about 45 to 25 percent or less.

Weekly hours worked should decline with the rise in real wages, but the combined effects of hours worked and wages per hour on income are more difficult to determine. Weekly hours worked did decline one-third from 1900 to the early 1930's. Their leveling off at 40 hours since the 1930's is a puzzle.

The stock of human capital should increase relative to the stock of physical capital. Human capital in constant dollars increased annually at about 4 percent for education and a strong 5 percent for on-the-job training from 1929 to 1957. These compare with a 2-percent annual rate of growth in reproducible tangible wealth.

We can draw specific implications for human capital. People invest in themselves for future earnings and satisfactions. By doing so, they become capitalists. These investments in human capital, moreover, increase the economic efficiency of each person.

Professor Theodore W. Schultz of the University of Chicago presented the first lecture in the ERS Bicentennial Year Lecture Series on March 23, 1976. The above notes summarize his remarks.

PRICE SPREADS FOR FOOD: QUALITY OF THE DATA

Quality of agricultural data has been a concern for several years. One of the groups of agricultural economists that has focused on this subject is the Economic Statistics Committee of the American Agricultural Economics Association. Its most recent study, conducted by a task force that was sponsored jointly with the Economic Research Service, is available in a report entitled "Review and Evaluation of Price Spread Data for Foods."

This group studied four closely related economic data series produced by the Economic Research Service. These are the farm-retail price spreads for the food market basket, price spreads for individual foods, cost and profit components of the price spreads for individual foods, and the food marketing bill. The task force report provides a very useful guide to the methods used in constructing these data series, the proper uses and interpretations of the data, suggestions for changes and improvements in the data, and recommendations for additional types of information needed on the processing-wholesaling-retailing sector of the food industry.

Many important questions about the economic situation and performance of the food industry have been in the limelight since 1972. Some of these questions are answered or monitored well by these four data series:

- Are prices for farm products changing at the same time and by the same amount at all levels of sale from farmer to consumer?
- What share of the consumer's food dollar goes to the farming function at any point in time?
- How much of the annual consumer food expenditure for U.S. farm-produced food pays for different inputs or different processing and distribution functions?

Some questions are not answered by the four series. Efficiency of the food processing and distribution industries, and the "fairness" of profits earned by firms in these industries, are examples. One of the more frequent incorrect uses of the data is the attempt to draw precise inferences from them about the size and equity of profits earned by food processing and distribution firms. Several recommendations made by the task force consider this improper use of price spread data and the need for more information on industry performance:

1. Every attempt should be made to keep data users informed about the correct and incorrect uses of the data series. Conceptual differences between price spreads and marketing margins represent one important area, the understanding of which should be stressed to all users.

2. The degree to which detailed cost and profit components are calculated and published on individual foods should be reduced. The conceptual differences between price spreads and market margins make the component calculations a rough approximation at best. The task force felt that many users of these data improperly took this information to provide the answers to their questions on size and equity of industry profits.

3. ERS should seek industry cooperation in constructing new data series on actual marketing margins and related cost components.

4. Profit data from more firms in the industry should be included in information now compiled on industry profits. Additional measures of profit performance, such as the relationship of profits to total assets, would also be useful.

5. Additional research studies by economists to shed more light on the relationships between price spread and market margin data would be very useful. These studies might examine the importance of inventory handling and accounting methods, price specialing and other pricing behavior, seasonality of some food products, and the different concepts and measures of profits used in the industry.

6. Other research studies by economists are needed on the productivity and performance of the industry. These studies should focus on the efficiency and food price impacts of product handling, and labor practices in the industry.

Other conceptual and measurement questions are addressed in the task force report. Important conceptual problems include the increasing conglomeration of economic functions into the same agency or firm, the disappearance of the farm gate as a pricing point for some products, and the meaning of "farmer's share" in the price spread data. Measurement problems discussed include calculations of physical conversion factors, use of lags in price spread calculations, problems with the retail food price data available from the Bureau of Labor Statistics (BLS) and calculation of a new market basket corresponding to new Consumer Price Indices to be available from the BLS in 1977.

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OFFBEAT READING FOR ECONOMIC INSIGHT

Economists have several reasons for reading. In common with other scientists they must read to keep up with professional progress. They must also read to improve their own thinking, and, perhaps, their writing as well.

This paper is mainly concerned with the kind of general reading that is good for economists, but which lies off the routine beat of the working day. Much of it may not seem to have any practical application. But it is the kind that results in the mind stretching, wrenching, and jolting that fires the imagination and brings forth new ideas. It is that which opens up new avenues and sends thought beyond the usual horizon. As Shackle recently put it: "Our lives are lived on the edge of the known world. For only that world is known which has already emerged into the past . . . all thoughts are in the present . . . we have to invent, to imagine . . . [to fill] the void of future time . . . (7, p. 37)." Imagination is the key.

THE WISDOM OF READING WIDELY

Economists need to read widely even more than other scientists because they are in greater danger of viewing the world as a well-ordered system of cycles and trends all ultimately reducible to mathematical formulas. But the real world refuses to be so neatly tamed. It is full of sudden shocks and surprises, many quite unpredictable. Keynes understood this when he wrote:

> The theory of economics does not furnish a body of settled conclusions immediately applicable to policy. It is a method rather than a doctrine, an apparatus of the mind, a technique of thinking, which helps its possessor to draw correct conclusions (2).

Those who do not take positive steps to break away are all too likely to stay safely within the confines to which they are accustomed. Reading beyond the call of professional duty is one way out. Almost any reading can help open new vistas, improve your thinking, suggest new methods of analysis, and add interest and appeal to your writing. Even dull reading may lead to a firm resolution not to write dully. A vivid, lively style may rub off and improve your own next manuscript. Some of

this comes about by unconscious absorption and some by careful effort. From time to time, we need to shake up our prejudices to keep them from hardening into fixed patterns. As I once wrote:

> All of us need to be on guard to avoid seeing current events through the windows of yesterday. It is as though we carried about with us mental television screens equipped with sets of colorful old films, and, when we think we are seeing the world as it is, some psychological circuit closes and we are merely rerunning well-worn films out of the past. Our preconceived ideas of things prevent us from seeing them as they actually are. The familiar mental picture comes between us and the actual object, character, or event (*3*).

On a very basic level, such offbeat reading may help in understanding broad philosophical questions related to research methods and procedures. To illustrate, let us look now at three quite different references, a short story, a short novel, and a guidebook to a more perfect society. The first was written more then a century ago, the second in the 1920's, and the third in between. Every economist has probably read at least one of them. But if they were read in high school or early on, much may have been missed. Each is worth reading again.

THE PURLOINED LETTER (*6*)

Most of Edgar Allan Poe's stories stimulate imagination. Every boy or girl who reads *The Gold Bug*, without quite knowing it, receives an elementary lesson in statistics in the process of decoding a secret message about buried treasure. But *The Purloined Letter* is a tale that no economist should miss. It sets up two sharply contrasting ways for solving a problem. One is statistical, the other logical. In this instance, the problem is the mysterious hiding place of a compromising letter.

The Parisian police who conduct the search are exceedingly able in their way. "They are persevering, ingenious, cunning, and thoroughly versed in the knowledge which their duties seem chiefly to demand." They do their work carefully, examining every square inch of the palace in which the missing letter is known to be hidden. They probe the walls and the furniture, search for secret drawers, and in the end find nothing. The Prefect of Police seeks counsel and advice from M. Dupin, the detective hero, who finds the letter almost immediately. It lies in the open, thrown carelessly on a card rack along with several calling cards and other miscellaneous trivia. It is so obvious that the zealous searchers have missed it entirely.

M. Dupin's method is a form of game theory, one of reading the mind of the politician who stole the letter, and reasoning about how he would act. The stark contrast of the two methods may be unfair to the meticulous procedures which are certainly necessary on many occasions, but it points up the need for combining logic and statistics. How often in recent years have we seen a model superbly constructed and internally consistent, which failed utterly because its basic assumptions did not allow for certain contingencies? So much for the short story. Now for the short novel.

THE BRIDGE OF SAN LUIS REY (*8*)

The Bridge of San Luis Rey by Thornton Wilder appeared in 1927 and won a Pulitzer price. It has little to do with economics, but every economist should have something to do with it. Wilder provides an interesting excursion into the realm of the unknowable. The book carries more than one message and one is aimed at social scientists in general. Though serious, the story also has elements of satire.

The plot turns around "the finest bridge in all Peru," the Bridge of San Luis Rey, woven of osiers more than a century before by the Incas and named for St. Louis of France. "The bridge seemed to be among the things that last forever; it was unthinkable that it should break." Yet one hot summer day in 1714 it did break just at noon and five people who were crossing fell to their deaths in the chasm beneath.

By coincidence the accident was witnessed by Brother Juniper, a Franciscan engaged in converting the Indians in remote villages. He was a man of inquiring mind who in the course of his journeys about the country had developed various hypotheses to explain the workings of Providence. It sometimes seemed to him that the good were often called from this life earlier than the not so good. Several times he had developed and tested schedules of questions in an effort to get behind the mystery but always some unexpected circumstance interfered with a clear demonstration of the principle that he was searching for. Here might be a less complicated case, in which it would be possible to discern why these particular five were chosen out of all the others who had passed that way. By investigating their lives, he might find the hidden reason for their sudden taking off. Here was his hypothesis, here his providential laboratory. He drew up an open-ended schedule and busied himself for 6 years knocking on the doors of all those in Lima who had known the victims, asking thousands of questions about their past lives. All this activity resulted in an enormous volume which was later burned publicly by the Inquisition along with Brother Juniper himself. Only chance preserved a second copy that was hidden away and saved for posterity.

Wilder's novel is concerned with the differences between what Brother Juniper's investigation elicited and what really happened in the lives of each of the five individuals. For all his diligence, he never learned the central passions that moved each character's life. Despite the thousands of detailed facts and testimonies, he never got to the bottom of things. Moreover, he was never even aware that he had failed in his mission and came to the end firmly believing he had made a significant contribution to the faith.

When I first read this novel in 1929, its full meaning did not reach me. Some years later, another reading hit me more forcefully. By then I had had more experience with questionnaires and was more aware of what can and what cannot be accomplished in personal interviews. Reading Oskar Morgenstern's classic, *On The Accuracy of Economic Observations* (*5*), recently reminded me again of some of the limits of such sources of information. Data are not always what they seem. You must know their history, how they were gathered, put together, used and misused.

LOOKING BACKWARD (*1*)

When Edward Bellamy wrote *Looking Backward* in 1887, he was really looking forward toward a better tomorrow. The main character in his story is a young man of 30, a very proper Bostonian named Julian West. Mr. West is mysteriously carried forward in time 113 years to the year 2000. From that vantage point he looks backward and describes the progress that society and the economy have made. Through what Bellamy called nationalism and we should probably term a form of socialism, the world has been transformed from a place of war and poverty to one of peace and plenty. Both at home and abroad, strife and discord have vanished and all sorts of new technologies have arisen to speed productivity and economic efficiency. Economic goods and well being are more evenly distributed. The technological achievements are perhaps the most striking. Bellamy's foresight in this respect is almost uncanny; but his optimism about changes in human nature and welfare has not been well realized.

John Dewey, Charles Beard, and Edward Weeks in 1935 rated *Looking Backward* as the most influential work by an American in the preceding 50 years. They concluded that it was second only to Karl Marx's *Das Kapital* on a worldwide basis. It is one of the few books that immediately sparked a mass political movement; Bellamy Clubs sprang up all over the Nation and the forces thus set in motion were one of the factors behind the Populist Party. The book's significance is now mainly historical, but the quality of the writing and the author's distant vision on technology still give it special value to economists concerned with projections. It is a story that stirs the imagination and illuminates the basic attributes of all utopian concepts.

CONCLUSION

Economists need to read and read widely to expand their imaginations and to see beyond the limits to which they are all too likely to be comfortably accustomed. But beyond all else, they need to read to gain better understanding and command of their methods and models.

We have looked briefly at *The Purloined Letter*, *The Bridge of San Luis Rey*, and *Looking Backward*. You can find many others. Some prefer Sherlock Holmes or Agatha Christie, others choose Shakespeare, still others find something else. Whatever you like best may work best for you. But do read or read again *The Purloined Letter*, *The Bridge of San Luis Rey*, and *Looking Backward*. An evening or two so spent will be rewarding.

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